

# PALESTINE JOURNAL OF BOTANY

*Jerusalem Series*

EDITED BY

THE STAFF OF THE DEPARTMENT OF BOTANY OF THE HEBREW UNIVERSITY

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J E R U S A L E M  
I S R A E L

**PALESTINE JOURNAL OF BOTANY**

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Edited by the Staff of the Department of Botany of the Hebrew University, Jerusalem. Each volume of the JERUSALEM SERIES comprises four issues, two issues appearing per annum the size of the volume varying from 250 to 350 pages.

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Edited by H. R. OPPENHEIMER and I. REICHERT, Agricultural Research Station, Rehovot, Israel. Each volume of REHOVOT SERIES comprises two issues, the size of the volume varying from 200 to 250 pages.

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STRUCTURE AND ECOLOGY OF THE VEGETATION  
IN THE DEAD SEA REGION OF PALESTINE

By M. ZOHARY AND G. ORSHANSKY

(With Plate IV, 1 map and 10 figures in the text)

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The present paper is a summary of an ecologico-vegetational analysis of one of the largest halophytic centres of the Near East. This area constituting the deepest continental depression of the globe and harbouring one of the saltiest seas of the world, has long attracted tourists and collectors but its ecological peculiarities remain unknown. A series of ecological investigations in this area were recently published by EIG (1946) and SHMUEL (1948).

The principal aims of the present study are to delimit the plant communities within the intricate vegetational mosaic, to bring to light the ecological factors which account for the diversity of the vegetation and to compile a vegetation map of the area.

The work was carried out during the years 1942-1945.

### (i) *Location and topography*

The area under investigation comprises the N. part of the Dead Sea shore and the adjacent part of the Jordan Valley. It is bordered on the east by the Jordan River and the Dead Sea, on the west by the eastern slopes of the Judean Desert and on the north by the great oasis of Far'a; Ain Feshkha is the southern limit.

The area consists of an alluvial-colluvial plain sloping gently from a height of -250 m. in the west to -392 m. at the Dead Sea shore. This plain may be roughly subdivided into three longitudinal terraces varying in breadth: (a) The Upper Terrace, (b) the Lower Terrace and (c) the Flood Terrace of the Dead Sea and the Jordan River. While the terraces themselves are more or less smooth in topography, the transition belt between them, the "Broken Lands" of the geologists, are strongly marked by erosion and constitute the most conspicuous topographical feature.

A few greater water courses form at the great Upper Terrace oases, which differ strikingly from the adjacent salines by their deep, non saline soil. On the Lower Terrace the soils are more saline due to the presence of some saline springs, ephemeral marshes and a high underground water table.

### (ii) *Climate*

The desert climate of the area is characterized by a short, mild winter and a long, dry and hot summer (Fig. 1). The average annual rainfall in Jericho is 116,5 mm., at the Allenby Bridge (on the Jordan) 101,4 mm., on the N. Shore of the Dead Sea (Kallia) 65,2 mm. and at Far'a, the northernmost point of the area, about 140 mm. The rainy season is from November to April; the heaviest falling in January and February. Fluctuations in the annual rainfall are very considerable. Jericho, for instance, had 61 mm. of rain in 1932, in 1938 — 196 mm. The number of days with more than 1 mm. rain varied between 46 (1938) and 20 (1927).

The mean maximum temperature of the hottest month (June) is 38,1°C and the mean minimum of the coldest month (January) is 9,8°C, the absolute minimum being 1,3°C and the mean annual temperature 23,1°C. All these data refer to Jericho, while for the N. shore of the Dead Sea figures of temperature are somewhat higher. The

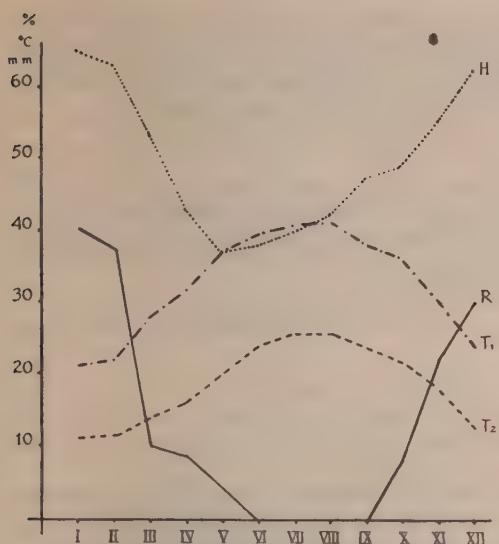


Fig. 1. Annual curves of rainfall (R), temperature (mean maximum —  $T_1$ , mean minimum —  $T_2$ ) and relative humidity (H) at Jericho.

annual mean of relative humidity is in Jericho 51% and at the Dead Sea — 61%.

All the above figures are taken from ASHBEL (1938, 1944, 1945).

### (iii) Soil

The surface deposits of the area consist of the so-called "Lissan Marls", containing among others a sizable amount of lime, gypsum and a variety of soluble salts, notably chlorides. This parent rock is at present overlain by alluvial and colluvial matter transported from the adjacent mountains in the west and partly also drawn down from the Upper to the Lower Terrace (Fig. 2).

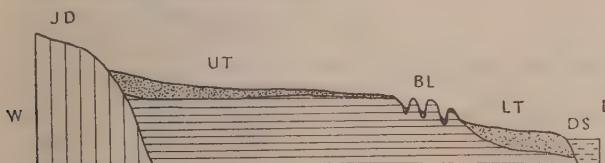


Fig. 2. Schematic WE transect of the area (along the main road to Kallia) showing the comparative depth of soil marked in dots. (JD—Judean Desert; UT—Upper Terrace; BL—Broken Land; LT—Lower Terrace; DS—Dead Sea).

With the exception of the oases the area under review is a vast salt land of the solonchak type, the predominating salt being  $\text{NaCl}$  followed by  $\text{MgCl}_2$ ,  $\text{CaCl}_2$ ,  $\text{CaSO}_4$ , etc. The primary source of these salts are the "Lissan Marls", which under the local desert conditions

could not be leached out. In the Lower Terrace saline springs and the high table of underground water are additional sources of salinization.

A number of soil varieties can be distinguished here according to degree of salinity, soil moisture, mechanical constitution, etc.

### (1) *Salinity*

The amount of soluble salts ranges generally from 0,2% up to 15% but may also be as high as 31,13% (PUFFELES, 1936) as referred to dry matter. The composition of the soluble salts is, according to MENCHIKOVSKY (1930), as follows:

depth in cm.	Na	K	Mg	Ca	Cl	HCO <sub>3</sub>	SO <sub>4</sub>	total	total soluble salts
0—25	0,046	—	0,03	0,32	0,021	0,032	0,82	1,26	1,26
25—50	0,637	0,095	0,63	0,67	3,12	0,032	1,18	6,36	6,45
50—75	4,390	0,160	0,75	1,18	9,65	0,032	1,44	17,60	17,61

While these data show that the amount of soluble salts increases strikingly with the depth of soil, the data of PUFFELES (1936), who has examined several profiles along the Jericho—Allenby-Bridge road, show that there is no general rule in this respect. Our examinations and in part those of RAVIKOVITCH (1946) point out that in the hydromorphous saline the salts decrease with the depth, while in the automorphous saline the opposite is the case.

The following figures have been found by us in soils under various plant associations between Jericho and the Dead Sea (percentage refers to air-dry soil):

Vegetation	depth in cm.	total soluble salts in %	Cl in %
1. oases, assoc. of <i>Zizyphus-Balanites</i> or under cultivation	10	0,06	0,0043
	50	0,22	0,053
	80	0,07	0,0089
2. assoc. of <i>Salsola villosa</i> — <i>Stipa tortilis</i> ( <i>subsegetale</i> )	15	0,16	0,0017
	40	0,16	0,0018
3. assoc. of <i>Salsola villosa</i> — <i>Stipa tortilis</i> ( <i>typicum</i> )	15	1,94	0,97
	40	2,34	1,05
4. assoc. of <i>Anabasis articulata</i> — <i>Notoceras bicornis</i>	15	1,34	0,37
	40	1,97	0,25
5. <i>Salsoletum tetrandrae</i>	15	1,78	0,43
	40	2,20	0,51
6. <i>Suaedetum palaestinae</i>	15	2,99	1,04
	40	3,02	0,85
7. <i>Salsoletum Rosmarini</i>	15	2,78	0,77
	40	2,82	0,73
8. assoc. of <i>Arthrocnemum glaucum</i> — <i>Tamarix tetragyna</i>	15	7,51	2,86
	40	5,78	2,17
9. plantless soil	15	17,52	8,81
		40	11,64
			6,10

In the above table association 1. is confined to non saline agricultural oasis soil; 2. is confined to the same soil less intensively cultivated; 3-5. occupy the automorphous salines of the Upper Terrace; 6-7. are confined to the hydromorphous soil with a high water table in winter but never inundated; 8-9. are marshy and submerged for some time in winter.

The above figures show clearly that in the hydromorphous series the amount of soluble salts is considerably higher than in the automorphous and that in the former the amount decreases or does not alter greatly with the depth, while in the latter it increases markedly with the depth (see also Fig. 3).

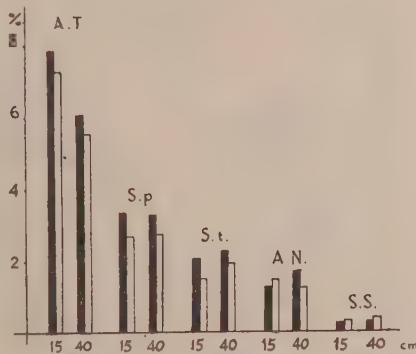


Fig. 3. The salt content in percent of air dry soil in soils under various associations at a depth of 15 cm, and 40 cm. in summer (left column) and in winter (right column). A.T.=assoc. of *Arthrocnemum*—*Tamarix*; S.p.=*Suaedetum palaestinae*; S.t.=*Salsolietum tetrandrae*; A.N.=assoc. of *Anabasis*—*Notoceras*; S.S.=Assoc. of *Salsola tetrandra*—*Stipa tortilis*.

## (2) Moisture relations of the soil

The annual precipitation, however scanty, greatly affects surface soil moisture which alone supports the annuals. Precipitation also indirectly affects the yearly and seasonal shifting of the ground-water horizon which is decisive upon the perennials of certain communities. The shifting of the moisture content is therefore striking in the automorphous salines and less obvious in the hydromorphous ones as seen from Fig. 4.

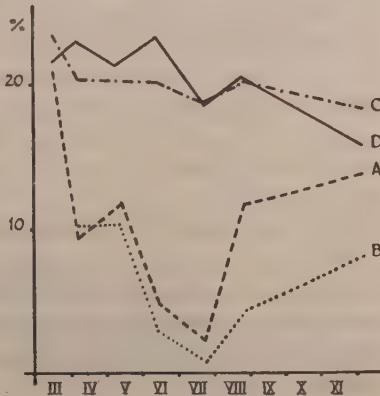


Fig. 4. Annual curves of soil moisture in automorphous (A,B) and hydromorphous (C,D) salines at two depths (A,D=40cm; B,C=15 cm).

The differences in soil moisture between the plant communities are most striking for the month of June. In the hydromorphous series the *Arthrocnemum* — *Tamarix* association enjoys soil moisture of 20%, *Salsoletum Rosmarini* — 12% and *Suaedetum palaestinae* 7%, whereas in the automorphous series 3,5% — 3,7% are the figures for *Salsola* — *Stipa*, *Salsola tetrandra* and *Anabasis* — *Notoceras* respectively. The yearly progress of soil moisture in some plant communities is shown in Fig. 5.

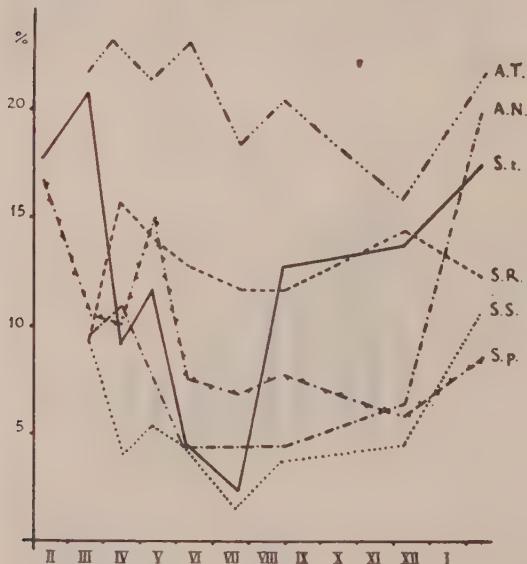


Fig. 5. Annual curves of soil moisture at a depth of 40 cm. in various plant communities (S.R. = *Salsoletum Rosmarini*; for other symbols see legend to Fig. 3).

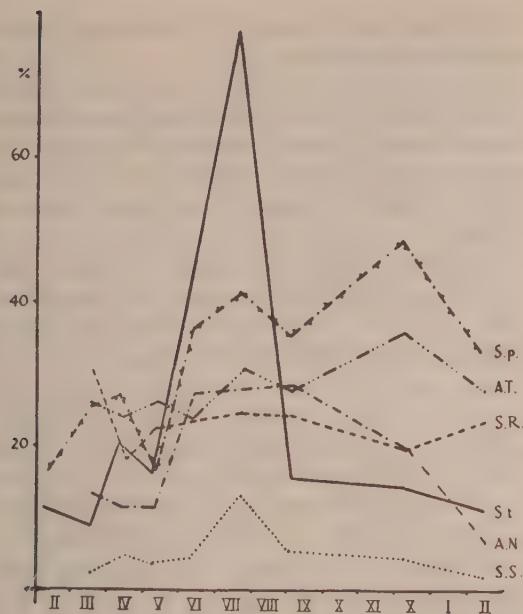
### (3) Mechanical composition of the soil

The mechanical composition of the soil varies with topography and distance from the mountains. Close to the mountains the soil is covered by and strongly mixed with pebbles and coarse stones giving the landscape a hammada-like aspect, elsewhere the soil is generally fine, dominated by silt and clay fractions (40—70%). For further details see RAVIKOVITCH (1946).

### (4) Concentration of the soil solution

The most important ecological factor is, no doubt, the concentration of the soil solution. Fig. 6 represents the seasonal changes in soil solution concentration for each community. In almost all plant associations there is a marked rise of the salt-moisture value in the summer months.

Fig. 6. Yearly march of concentration of soil solution in various plant associations calculated from the total soluble salts and moisture content. (For symbols see legend to Fig. 3).



### (5) Soil classification

From the above data it is obvious that soil classification within the reviewed area must be based on the relation between moisture and soluble salts of the soil. The following varieties, also manifested by vegetation, may easily be distinguished:

(a) *Alluvial soils*. Alluvial, well drained soils free from injurious salts and consisting mostly of deep loams transported from adjacent or remote mountains. In their natural state they harbour a non halophytic Sudano-Deccanian vegetation; most of them are under cultivation (No. 1 on the map).

(b) *Saline soils*. Saline soils are subdivided into the following varieties:

(i) *Automorphus salines* of the Upper Terrace (Nos. 2-5) with a deep underground water table. The soil cover is either deep and gravelly or shallow and fine-textured. Average content of soluble salts 0,6—2,6%.

(ii) *Hydromorphus salines* comprising:

(a) *High water table salines* of the Lower Terrace (Nos. 6-9). It is a deep fine-textured soil, never inundated but sufficiently moist in winter due to the proximity of the underground water. It has a high

salt content and surface salt efflorescence in summer. Average content of soluble salts 3-6%.

(β) Seasonally submerged salines of depressions on the Lower Terrace (Nos. 10-12) in which water accumulates for 2 months or more during winter. In early summer they dry out and often show salt efflorescence. The soil is generally very deep, the average salt content is 6-14%. The flood region of the Jordan River may be included in this category.

(γ) Permanently wet salines comprising marshy and often peaty soils near permanent springs or brooklets with a considerable salt content. The flood region of the Dead Sea and partly also that of the Jordan River belong into this category (No. 13).

#### (iv) *Floristic composition*

The 187 species listed in over 100 records of the local vegetation belong to the following phytogeographical groups: Mediterranean — 11,7%; Irano-Turanian — 10%; Saharo-Sindian — 26%; Mediterraneo — Irano-Turanian — 31,6%; Irano-Turanian — Saharo-Sindian — 10%; Sudano-Deccanian — 2%; other groups — 10%. The mixed phytogeographical character of the flora in a typical Saharo-Sindian territory is a result of the edaphic factors of the habitats which are wide enough in range to support halophytic, hydrophytic, segetal and ruderal wades in addition to the true desert flora.

In comparison with other parts of Palestine the number of species is exceedingly low. This is especially conspicuous with perennials. The fact that the 187 species belong to 35 families, making an average of 5 species per family, is also striking when compared with the flora of Palestine as a whole, where this average is about 20. Of these families the *Chenopodiaceae* are represented by 25 species (among them 4 species of *Suaeda*, 5 of *Salsola*, 3 of *Atriplex*). The genus *Tamarix* is represented by 3 species, one of them endemic. *Leguminosae*, *Gramineae*, *Compositae* and *Cruciferae* are richest in species while other families are represented by 1-3 species only.

#### (v) *Life forms*

The species included in our records belong to the following biological forms (RAUNKIAER, 1934): Ph — 4,1%; Ch — 7,5%; H — 1,6%; C — 4,8%; Th — 82%. Compared with the general biological spectrum of Palestine (Ph — 5,4%; Ch — 7,6%; H — 23%; C — 12,8%; Th — 51,2% (EIG, 1931) these figures are striking in the high percentage of therophytes and the small number of hemicryptophytes.

Phanerophytes are very rare and confined to hydrohalophytic or Sudano-Deccanian associations. The most characteristic life forms here

are chamaephytes, the leading species of most associations. Many of them, though attaining a height of 1 — 1,5 m. cannot be classed under phanerophytes because their upper branches die away and are replaced by short summer shoots in the dry season. The most important chamaephytes are: *Salsola vermiculata* ssp. *villosa*, *S. tetrandra*, *S. Rosmarinus*, *Suaeda palaestina*, *S. fruticosa*, *Anabasis articulata*, *Atriplex Halimus*, etc.

Hemicryptophytes are very sparsely represented. Moreover, some hemicryptophytic species become therophytes in desert conditions or give off annual derivates. The commonly accepted opinion that geophytes are most characteristic of desert regions does not hold true, at least are our deserts, extremely poor in geophytes.

Therophytes, despite their abundance in number and coverage, hardly reflect the desert conditions. Their life cycle is confined to few months of the rainy season, in years of extreme drought they fail to appear. Their dimensions vary greatly according to the moisture conditions of the year.

Hemicryptophytes, geophytes and therophytes constitute a single ecologic group designated by interruption of life activities with the start of the dry season. They comprise about 90% of the flora, 10% leaving only for forms permanently exposed to the difficult desert conditions.

#### (vi) *Phenology*

The flowering time of the thero-, geo- and hemicryptophytes occurs in winter or in spring, whereas that of the chamae- and phanerophytes is not confined to the rainy season alone. In one and the same habitat *Suaeda palaestina* flowers in winter, *Statice pruinosa* in spring and *Prosopis farcata* in summer. Another example is *Tamarix* (3 species). Though all grow on moist salines, *T. tetragyna* flowers in winter, *T. jordanis* in spring and *T. maris-mortui* mainly in summer. The principal growth period of the chamaephytes falls in winter. Before shedding their leaves in early summer, short summer branches, bearing small leaves, develop in their axils. These summer branches are physiologically active during the dry season and with the start of the winter grow in length, producing winter leaves.

This seasonal alternation of shoots in chamaephytes is an outstanding phenological feature. In this connection it may be mentioned that the principle of bud topography and bud protection adopted by RAUNKIAER (l. c.) in classification of life forms does not hold true in local chamaephytes which, instead of protected buds, bear brachyblasts with smaller leaves in the dry season. By this seasonal heterophyly a considerable reduction of the transpiration surface of the plant during the dry period is achieved.

### (vii) Tolerance to salinity

The flora inhabiting the saline habitats of the area may be subdivided into the following groups:

(1) Obligatory halophytes: *Suaeda palaestina*, *S. monoica*, *S. fruticosa*, *Salsola Rosmarinus*, *S. tetrandra*, *Atriplex Halimus*, *Tamarix tetragyna*, *T. maris-mortui*, *Nitraria retusa*, *Statice pruinosa* and many others. Most of them are leading perennials of the associations. The annuals *Sphenopus divaricatus*, *Capsella procumbens*, *Tetradiclis salsa*, *Bassia eriophora*, *Schaginia baccata*, *Mesembryanthemum Forskahlei*, *Statice spicata* are to be included in this group. The degree of salinity tolerated by these plants ranges from 1% to 8% of soluble salts in the soil.

(2) Preferential halophytes also found in non halophytic habitats but less frequent there, are *Spergularia diandra*, *S. marginata*, *Aizoon hispanicum*, *Mesembryanthemum nodiflorum*, *Lepturus incurvatus*, etc.

(3) Tolerant halophytes, usually growing in non-halophytic habitats but tolerating salinity to some extent, are: *Stipa tortilis*, *Centaura hyalolepis*, *Plantago Coronopus*, *P. ovata*, *Statice Thouini*, *Aaronsohnia Faktorovskyi*, *Reboudia pinnata*, *Pteranthus dichotomus*, *Phalaris minor*, *Malva parviflora* and others. The perennials of this group are *Anabasis articulata*, *Salsola vermiculata* ssp. *villosa*, *Phragmites communis*, *Alhagi Maurorum*, *Prosopis farcata*. Fig. 7. demonstrates the amounts of soluble salts found at a depth of 40 cm. in habitats of certain leading species.

### (viii) Root habits

Among the perennials the four following main root types have been distinguished (Fig. 8):

(1) *Suaeda* type, represented by *Suaeda palaestina*, *Salsola tetrandra* and *Arthrocnemum glaucum*. The main vertical, very short root (5-25 cm.) forks into numerous horizontal branches running in the uppermost soil layer almost parallel to surface. There is no vegetative reproduction by subterranean shoots.

(2) *Salsola villosa* type. The tap root penetrates to a considerable depth (40-80 cm.) and then dissolves into thin horizontal or oblique laterals.

(3) *Anabasis* type. The tap root runs downwards to a depth of a few metres. Thick oblique laterals are given off at a considerable distance from the crown. Some of the laterals reach greater depth while others spread over broad areas. Finer branches are mostly limited to tips of the laterals. This type is found in *Anabasis articulata*.

(4) *Prosopis* type. The root system is designated by an exceedingly long vertical rootstock giving off more or less horizontal, wide-spread,

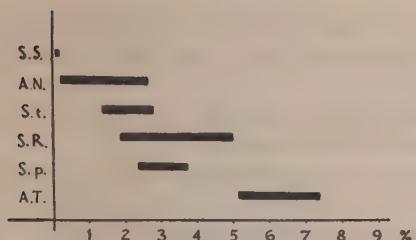


Fig. 7. Range of average soil salinity in percent of total soluble salts of air dry soil in various associations of the area. S.S.=assoc. of *Salsola*—*Stipa*; A.N.=assoc. of *Anabasis*—*Notoceras*; S.t.=*Salsolietum tetrandrae*; S.R.=*Salsolietum Rosmarini*; S.p.=*Suaedetum palaestinae*; A.T.=assoc. of *Arthrocnemum*—*Tamarix*.

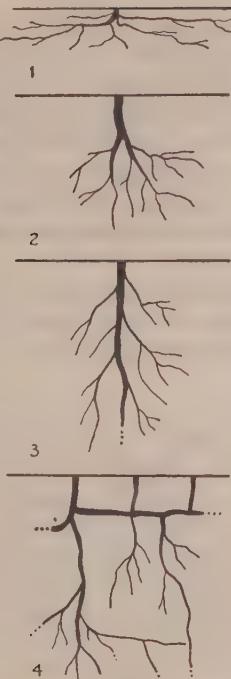


Fig. 8. A sketch of the four main root types of local chamaephytes and phanerophytes.  
 1 — *Suaeda* type; 2 — *Salsola* type;  
 3 — *Anabasis* type; 4 — *Prosopis* type.

rather thick laterals at a depth of 30-80 cm. The latter produce vertical shoots which in their turn may give off secondary horizontal laterals and so on. Both the horizontal and vertical shoots are provided with thin roots. The whole subterranean system thus attains sizable dimensions and may extend over hundreds of square meters. The plants reproduce vegetatively from these rootstocks. *Prosopis farcata*, *Alhagi Maurorum*, *Atriplex Halimus* and probably also some species of *Tamarix* belong to this type.

Observations of root habits and their relation to habitats led us to the following conclusion.

(1) The multitude of root forms in deserts, as described by CANNON (1924), EVENARI (1938) and others, may be reduced to a few basic forms. These forms are highly plastic as to dimensions and degree of ramification according to the constitution of the stratum.

(2) Desert plants are not necessarily deep-rooted. Much deeper roots have been found in the Mediterranean region than in the adjacent deserts.

(3) No fixed relation has been found between habitat and basic root pattern. In the stands of *Suaedetum palaestinae* three of the four

types of roots described above have been observed; in the stands of *Arthrocnemum* — *Tamarix* association shallow and deep rooted plants grow side by side.

(4) Succulents are not always shallow-rooted, as seen in *Anabasis articulata*, *Nitraria retusa* and *Suaeda monoica*.

(5) Referring to the figure on transpiration obtained by SHMUEL (1948) deep rooted plants (as *Prosopis*, *Tamarix*, etc.) show highest transpiration values, but no generalization should be made in this connection.

(6) There are also certain relations between deep rooting and osmotic value of cell sap. The latter is considerably lower in deep than in shallow-rooted plants.

#### (ix) Water balance

The water balance of some halophytes in the Dead Sea region has been studied by SHMUEL (1948). We approached this problem indirectly only, by examining the salt-moisture relations of the soil on the one hand and the osmotic value of the cell sap of the leading plants on the other. The data obtained by us are summarized in Fig. 9 (concentration of soil solution and osmotic value of cell sap) and Fig. 10 (yearly march of the osmotic values of cell sap).

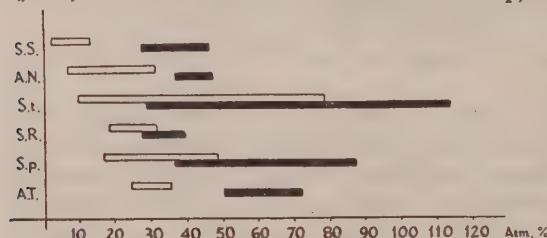


Fig. 9. Annual range of concentration of soil solution in percent at a depth of 40 cm. (white) and of osmotic values of cell sap in atm. (black). (For symbols see legend to Fig. 3).

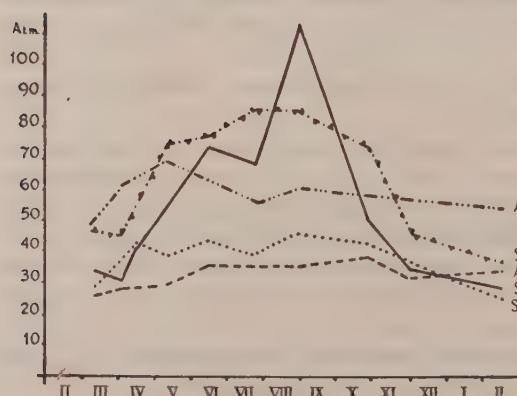


Fig. 10. Yearly march of the osmotic values of cell sap in atm. in some of the leading species. (A.g.=*Arthrocnemum glaucum*; S.p.=*Suaeda palaeistica*; A.a.=*Anabasis articulata*; S.t.=*Salsola tetrandra*; S.v.=*Salsola villosa*).

From these figures the following may be concluded:

(1) The lowest osmotic values are found in deep rooted plants, e.g. *Prosopis farcata*, *Alhagi Maurorum* (according to SHMUELI, 1948). The highest osmotic values have been found in shallow rooting plants, such as *Suaeda palaestina*, *Salsola tetrandra* and *Arthrocnemum glaucum*.

(2) Osmotic values are highest during the dry season in accordance with the moisture decrease in the soil. Where seasonal fluctuations in soil moisture are slight the annual curves of osmotic values are rather smooth.

(3) There are clear relations between the osmotic values of the cell sap and the concentration of the soil solution, although the latter as compiled here from salt-moisture figures does not represent the real state of this value in nature.

(4) No fixed relations have been found between degree of succulence and osmotic values of cell sap as seen from the curves of *Anabasis* (succulent) and *Salsola villosa* (Fig. 10).

Salt exudation is a common feature among halophytes, succulents and non succulents. KELLER (1925) for *Frankenia* and WALTER and STEINER (1936) for *Avicennia* arrived at the conclusion that by removing the exudated salt cover from the leaf surface the rate of transpiration decreases. We have examined this question on a dry summer day in the same habitat on three species of *Tamarix*, outstanding by reason of their heavy salt exudation, viz.: *Tamarix maris-mortui*, *T. tetragyna* and *T. articulata*. They were treated as follows: Branches attached to the tree were washed thoroughly to remove their salt cover and left to dry. Transpiration measurements were made from washed and salt covered branchlets of the same tree at the same height and exposure. The transpiration rate of *T. maris-mortui* and *T. tetragyna* was greater in salt covered branches than in the washed ones, while in *T. articulata* the reverse was the case. The same results as in *T. articulata* were also obtained in *T. pseudo-Pallasii* in the coastal sand dunes. The fact that plants growing in the same habitat behave differently in this regard suggested that the salt cover of the leaves may have a different effect on transpiration in various species and that the observations hitherto made in this field are insufficient.

#### (x) Delimitation of vegetational units

As in other edaphically specialized communities exhibiting a belting arrangement the subdivision of the local vegetation into phytosociological units offers great difficulties. The first question is how to delimit the individual associations within the zonation complexes — which of the links in these complexes are typical and which transitional.

Another difficulty lies in the fact that within the association fragments a series of micro-habitats, each with plants of their own may occur. For instance one finds within the *Salsoletum tetrandrae* at least three different habitats: one occupied by *Salsola* (on hillocks with a medium amount of salt in the soil), the second represented by flat, less saline patches with a hardened crust supporting most of the annuals; the third habitat has spots of structureless soil, highly saline and almost plantless. The association in this instance is thus very loose comprising several assemblages with little biotic interrelation.

Peculiar to this region is also the lack of stability in the composition of the association. As a matter of fact the number of species of the same plot changes from year to year depending on the amount of annual precipitation.

By far the greatest number of the annual associates are desertic and semidesertic wades with no specific ecological affinity to the halophytic habitat. Their presence in these habitats may be explained by the fact that they are limited to the rainy season only and do not come into contact with the extreme conditions of the halophytic habitat. One may thus scarcely find among them few regional or preferential characteristics of the association.

Another source of confusion is that within the main vegetation belts of the area small depressions, wadis and other water bodies give rise to a series of minor, secondary zonation complexes of vegetation interrupting the spatial sequence of the main belts.

The above serves to illustrate the complexity and interwoven character of the vegetation units. This and other difficulties could not be overcome without studying the ecological conditions of each complex and surveying and mapping the entire area before attempting an analytical study of associations.

#### (xi) *The plant communities*

The following plant associations have been distinguished and grouped in alliances:

- (1) *Acacion tortilidis*
  - (a) assoc. of *Zizyphus Spina Christi*—*Balanites aegyptiaca*
- (2) *Salsolion villosae*
  - (a) assoc. of *Anabasis articulata*—*Notoceras bicornis*
  - (b) assoc. of *Salsola villosa*—*Stipa tortilis*
  - (c) *Salsoletum tetrandrae*
- (3) *Atripliceto*—*Suaedion palaestinae*
  - (a) *Suaedetum palaestinae*
  - (b) *Salsoletum Rosmarini*
  - (c) *Atriplicetum Halimi (jordanis)*

- (4) *Tamaricion tetragynae*
  - (a) assoc. of *Arthrocnemum glaucum* — *Tamarix tetragyna*
  - (b) *Tamaricetum maris-mortui*
  - (c) *Suaedetum monoicae*
  - (d) *Nitrarietum retusae*
  - (e) *Suaedetum fruticosae*
- (5) *Junceto* — *Phragmition communis*
  - (a) *Phragmitetum communis*
  - (b) *Juncetum arabici*
- (6) *Populion euphratica*
  - (a) *Populetum euphratica*
  - (b) *Tamaricetum jordanis*
- (7) *Prosopidion farcatae*
  - (a) assoc. of *Prosopis farcata* — *Glycyrrhiza glabra*
- (8) *Nerion Oleandri*
  - (a) *Viticetum Agni-casti*

Many of the associations dealt with here have been published by EIG (1946) and their validity is reaffirmed here by additional records. Other associations (a few of them being rather fragmentary) are here described for the first time.

The plant lists of the associations recorded here consist of local alliance or association preferentials and high presence companions. True (exclusive) characteristic species have not been found for most of the associations. The figures in brackets following the name indicate presence percentage.

(1) *Acacion tortilidis*, EIG 1946 (No. 1)<sup>1</sup>

This alliance is represented here by the association of *Zizyphus Spina-Christi* — *Balanites aegyptiaca* which is confined to oases in the outlet region of greater wadis (W. Kelt, W. Auja, W. Far'a). These oases, mostly under cultivation are designated by non-saline soils transported from the adjacent mountains. Some analytical figures concerning these soils are given on p. 180.

The primary structure and composition of the *Zizyphus* — *Balanites* association is not sufficiently known and the following species are, no doubt, remnants which have escaped extermination by man due to their deep roots and vigorous regeneration. The local characteristic species of this association are: *Zizyphus Spina-Christi*, *Balanites aegyptiaca*, *Calotropis procera*, *Solanum incanum*. The characteristics of the alliance are: *Boerhavia plumbaginacea*, *Acacia Raddiana* and *Salvadora persica* (the latter is rather rare here), etc. Where cultivated land is abandoned a segetal variety of the *Salsola villosa* — *Stipa tortilis* association develops.

<sup>1</sup> Numbers in brackets refer to the legend of the accompanying map.

(2) *Salsolian villosae*, EIG, 1946 (Nos. 2-5)

This alliance comprises in Palestine (EIG, 1.c.) four Saharo-Sindian associations, two of which are represented in this region, viz.: assoc. of *Salsola villosa* — *Stipa tortilis* and assoc. of *Anabasis articulata* — *Notoceras bicornis*. One must, however, include within this alliance also the *Salsoletum tetrandrae* considered by EIG (1.c.) as a special alliance. All of them are confined to compact but well aerated soil, sometimes covered or intermingled with pebble and gravel. All are limited to the Upper Terrace designated by the scarcity of soil moisture and medium amount of soluble salts increasing with the depth. According to their ecological requirements the associations of this alliance may be classed under the xerohalophytic type.

*Salsola vermiculata* ssp. *villosa*, *Salsola tetrandra*, *Anabasis articulata*, *Gymnarrhena micrantha*, *Silene setacea*, *Allium modestum*, *Scilla Hanburyi*, *Picris intermedia*, *Notoceras bicornis*, etc. are regional and preferential characteristics of the alliance.

(a) Assoc. of *Anabasis articulata* — *Notoceras bicornis*, EIG, 1946. (Plate IV A)

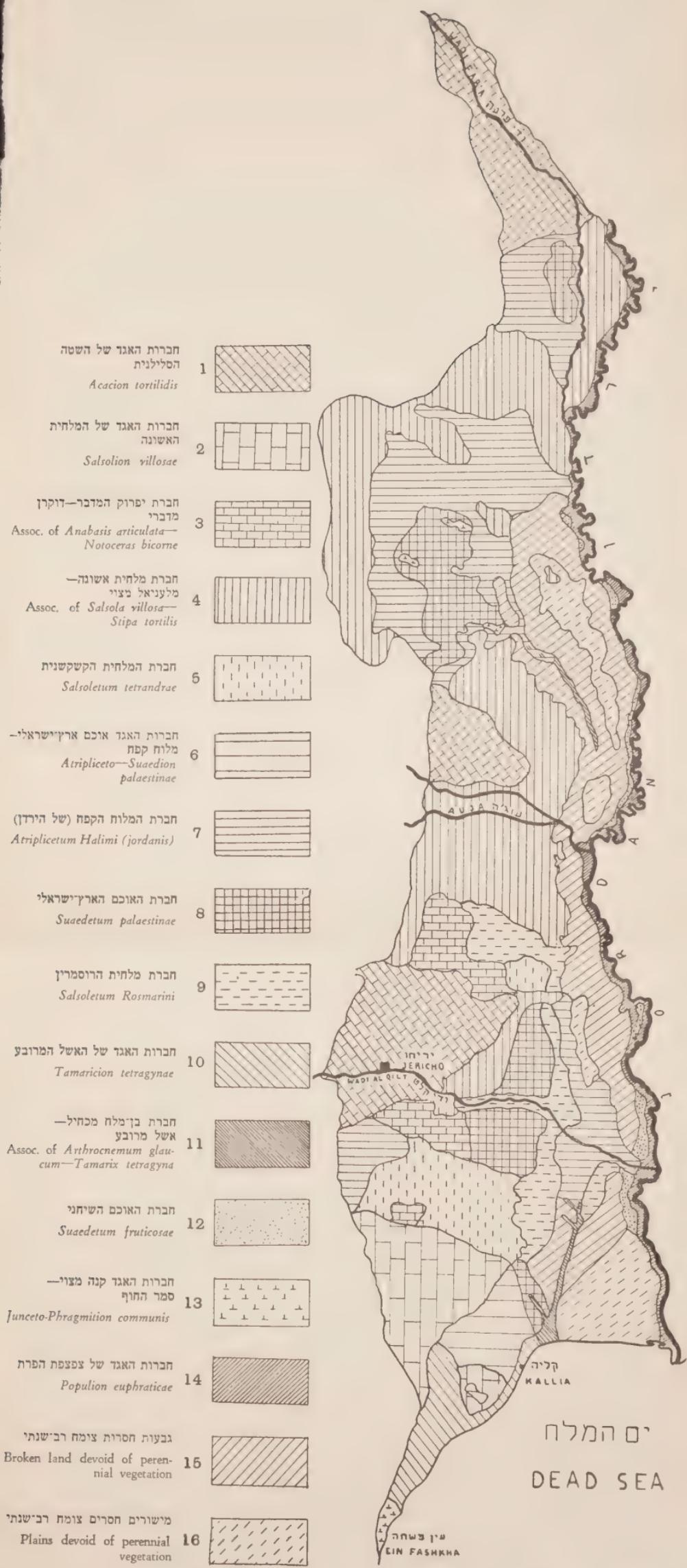
This endemic association occupies three isolated plots. The soil is rather deep and gravelly and slightly saline. The 6 records taken comprise 66 species, none of them characteristic (exclusive or preferential) of the association. General coverage 10—30% (for further details on edaphic conditions see p. 180 and Figs. 3, 5, 6, 7). Here are the most important species arranged according to their presence percentage (figures in brackets):

<i>Anabasis articulata</i>	(100)	<i>Minuartia picta</i>	(66)
<i>Notoceras bicornis</i>	(100)	<i>Picris intermedia</i>	(66)
<i>Stipa tortilis</i>	(100)	<i>Gagea rigida</i>	(66)
<i>Astragalus callichrous</i>	(100)	<i>Gymnarrhena micrantha</i>	(66)
<i>Plantago ovata</i>	(100)	<i>Erythrostictus palaestinus</i>	(66)
<i>Aaronsohnia Faktorowskyi</i>	(100)	<i>Asphodelus micranthus</i>	(50)
<i>Pteranthus dichotomus</i>	(100)	<i>Astragalus tribuloides</i>	(50)
<i>Asteriscus pygmaeus</i>	(80)	<i>Erodium deserti</i>	(50)
<i>Stathys Thouinii</i>	(80)	<i>Medicago laciniata</i>	(50)
<i>Plantago Coronopus</i>	(80)	<i>Reseda decursiva</i>	(50)
<i>Spergularia diandra</i>	(80)	<i>Papaver Rhoeas</i>	(33)
<i>Reichardia tingitana</i>	(80)	<i>Pterocephalus involucratus</i>	(33)
<i>Trigonella stellata</i>	(80)	<i>Allium hierochuntinum</i>	(16)
<i>Filago prostrata</i>	(80)	<i>Allium modestum</i>	(16)
<i>Scilla Hanburyi</i>	(66)	<i>Silene setacea</i>	(16)

*Anabasis*, a leafless shrub, 30-60 cm. high, with jointed, succulent shoots and deep roots is the only chamaephyte of the association; the remainder are therophytes and geophytes, mostly Saharo-Sindian species.

(b) Association of *Salsola villosa* — *Stipa tortilis*, EIG, 1946

This is the dominant association of the area under review. It covers vast stretches between Jericho and Wadi Far'a and is generally confined





to the Upper Terrace of the plain where it grows on alluvial-colluvial soil. Two forms of this association have been distinguished: one on saline soils between Jericho and Far'a and the other on non saline soils in or near the cultivated area of the Jericho oases. For further ecological characteristics of these habitats see p. 180, Figs. 3, 5, 6, 7, 9.

The general coverage ranges from 50—80%. Of the 95 species listed in the 12 records of this association not a single species could be indicated as characteristic of the association. Here is a list of some alliance preferentials and high presence companions (fig. in brackets = presence percentage).

<i>Salsola vermiculata</i> ssp. <i>villosa</i>	(100)	<i>Leontodon hispidulum</i>	(33)
<i>Stipa tortilis</i>	(100)	<i>Reboudia pinnata</i>	(33)
<i>Centaurea hyalolepis</i>	(80)	<i>Statice Thouinii</i>	(33)
<i>Koeleria phleoides</i>	(80)	<i>Asteriscus pygmaeus</i>	(25)
<i>Plantago ovata</i>	(80)	<i>Echium judaeum</i>	(25)
<i>Aizoon hispanicum</i>	(60)	<i>Erythrostictus palaestinus</i>	(25)
<i>Asphodelus tenuifolius</i>	(60)	<i>Evax palaestina</i>	(25)
<i>Astragalus callichrous</i>	(60)	<i>Crepis arabica</i>	(25)
<i>Calendula aegyptiaca</i>	(60)	<i>Gymnarrhena micrantha</i>	(25)
<i>Erodium aegyptiacum</i>	(60)	<i>Matthiola longipetala</i>	(25)
<i>Filago prostrata</i>	(60)	<i>Mesembryanthemum nodiflorum</i>	(25)
<i>Plantago notata</i>	(60)	<i>Notoceras bicornis</i>	(25)
<i>Pteranithus dichotomus</i>	(60)	<i>Schismus calycinus</i>	(25)
<i>Plantago Coronopus</i>	(50)	<i>Allium modestum</i>	(16)
<i>Bellevalia desertorum</i>	(42)	<i>Arnebia decumbens</i>	(16)
<i>Richardia tingitana</i>	(42)	<i>Attractylis cancellata</i>	(16)
<i>Trigonella stellata</i>	(42)	<i>Silene setacea</i>	(16)
<i>Anthemis maris-mortui?</i>	(33)		

*Salsola* is the only chamaephyte. All the others are therophytes and geophytes, many of them widely distributed all over desertic and sub-desertic associations of the Near East. *Stipa* has a high coverage.

In the segetal form of this association single trees of *Zizyphus Spina-Christi* are sometimes encountered inside or near the plots. It approximates the type in composition except for the occurrence of some segetal species such as *Diplotaxis erucoides*, *Anagallis coerulea*, *Beta vulgaris*, *Cichorium pumilum*, *Onobrychis squarrosa*, etc. *Stipa* never attains high coverage here.

*Salsola vermiculata* ssp. *villosa* is the leading shrub 20-30 cm. high. It has linear subulate lower leaves and scale-like succulent upper leaves. It has a well developed root system. The osmotic value of the cell sap is as follows: max. 45,9, min. 27,4, average 39,0 atm.

#### (c) *Salsoletum tetrandrae*, EIG, 1946 (No. 5) (Plate IV B)

This association occupies the easternmost zone of the Upper Terrace as well as flat tops of the hills in the "Broken Land" belt. It reaches its northern limit at the latitude of Ain Douk near Jericho. It is designated edaphically by series of characteristics, e.g. the rather shallow soil layer is cut up from the parent rock by a gypseous crust; the degree of the

soil salinity is generally higher than in the two above associations; there is clear differentiation of the surface soil into a mosaic of dark and bright patches, the former a loose almost structureless soil more saline than the latter<sup>1</sup> (see also p. 180 and Figs. 3, 5, 6, 7, 9). Floristically as well as edaphically this association forms a link between the *Salsolion* and *Suaedion*. The total number of species listed in 11 records of this association amounts to 71. The general coverage is 30-70%.

<i>Salsola tetrandra</i>	(100)	<i>Crepis arabica</i>	(45)
<i>Stipa tortilis</i>	(100)	<i>Erodium deserti</i>	(45)
<i>Plantago ovata</i>	(90)	<i>Herniaria cinerea</i>	(45)
<i>Trigonella stellata</i>	(90)	<i>Leontodon hispidulum</i>	(45)
<i>Aaronsohnia Faktorowskyi</i>	(81)	<i>Schismus calycinus</i>	(45)
<i>Aizoon hispanicum</i>	(81)	<i>Anthemis maris-mortui</i>	(36)
<i>Mesembryanthemum nodiflorum</i>	(81)	<i>Astragalus cruciatus</i>	(27)
<i>Reichardia tingitana</i>	(81)	<i>Astragalus tribuloides</i>	(27)
<i>Filago prostrata</i>	(72)	<i>Evax palaestina</i>	(27)
<i>Pteranthus dichotomus</i>	(72)	<i>Spergularia marginata</i>	(27)
<i>Spergularia diandra</i>	(72)	<i>Erodium hirtum</i>	(18)
<i>Astragalus callichrous</i>	(63)	<i>Erythrostictus palaestinus</i>	(18)
<i>Centaurea hyalolepis</i>	(63)	<i>Chlamydophora tridentata</i>	(18)
<i>Gymnarrhena micrantha</i>	(63)	<i>Iris Sisyrinchium</i>	(18)
<i>Reboudia pinnata</i>	(63)	<i>Lagoseris obovata</i>	(18)

The only chamaephyte is *Salsola tetrandra* which always shows high coverage and sociability. Despite the lack of exclusive characteristic species the association is so clearly delimited that EIG (1.c.) classed it under a separate alliance.

*Salsola tetrandra*, the leading species, is a strongly branching shrub with small scale-like fleshy leaves and shallow root system of type 1 (p. 187).

(3) *Atripliceto—Suaedion palaestinae* (= *Suaedion palaestinae*, EIG 1946) (Nos. 6—9)

This alliance comprises three associations: *Suaedetum palaestinae*, *Salsoletum Rosmarini* and *Atriplicetum Halimi (jordanis)*. These are confined mainly to the Lower Terrace and partly also to wadis, depressions and moist places of the Upper Terrace. Requiring a considerable amount of soil moisture and tolerating a higher degree of salinity than the associations of *Salsolion*, they may be classed under hydro-halophytic associations. The moisture is supplied to the soil through the high rise of the underground water table at least in winter. On the other hand they never tolerate submerged soil and in this they differ clearly from the associations of the *Tamaricion* and *Junceto-Phragmition* described below. The surface soil is generally spotted with dark and bright patches and salt efflorescence.

<sup>1</sup> In one of the samples examined the air dry surface soil of the dark patches has been found to contain 1,018% Cl while that of the bright ones — 0,349% of Cl.

Floristically this alliance is clearly designated by a series of regional and preferential characteristic species, e.g. *Suaeda palaestina*, *Prosopis farcata*, *Alhagi Maurorum*, *Bassia eriophora*, *Statice pruinosa*, *Malcolmia africana*, *Mesembryanthemum Forskahlei*, *Launea Foxii*, *Frankenia pulverulenta* and *Capsella procumbens*.

(a) *Suaedetum palaestinae*, EIG, 1946 (Plate IV C)

This association is very common in the southern sector of the area between Jericho and the Dead Sea. In the North it occurs mainly in the two great depressions between W. Auja and W. Far'a. The soil is generally soft and swollen in winter, dusty and structureless in summer. The bright patches of the ground are generally less saline and more populated by plants than the exceedingly saline dark patches<sup>1</sup>. For further details on salt and moisture relations of the soil see p. 180 and Figs. 3, 5, 6, 7.

EIG (1.c.) subdivided this association into three subassociations, viz.: *typicum*, *Staticetosum* and *Prosopidetosum*. The "typical" form is richest in number of species because it is linked between the *Salsolion* and *Suaedion* and because its soil is less saline. It also harbours a few shrubs, leading species of other associations.

The list of species recorded by EIG (1.c.) represents well the typical form of this association and needs not be quoted here again. The 20 records of this association collected by us from various parts of the area totals 75 species, none exclusively characteristic of the association.

Mention may, however, be made of local alliance preferentials and of high presence companions occurring within this association as a whole. These are:

<i>Suaeda palaestina</i>	(100)	<i>Statice spicata</i>	(35)
<i>Mesembryanthemum nodiflorum</i>	(90)	<i>Statice Thoubini</i>	(35)
<i>Spergularia diandra</i>	(80)	<i>Anthemis maris-mortui</i>	(30)
<i>Sphenopus divaricatus</i>	(70)	<i>Pteranthus dichotomus</i>	(30)
<i>Salsola tetrandra</i>	(65)	<i>Reichardia tingitana</i>	(30)
<i>Atriplex Halimus</i>	(50)	<i>Spergularia marginata</i>	(30)
<i>Plantago Coronopus</i>	(50)	<i>Leontodon hispidulum</i>	(25)
<i>Stipa tortilis</i>	(50)	<i>Malcolmia africana</i>	(25)
<i>Trigonella stellata</i>	(50)	<i>Tetradiclis salsa</i>	(25)
<i>Phalaris minor</i>	(45)	<i>Alhagi Maurorum</i>	(20)
<i>Prosopis farcata</i>	(45)	<i>Rumex dentatus</i>	(15)
<i>Schismus calycinus</i>	(40)	<i>Torularia torulosa</i>	(15)
<i>Plantago ovata</i>	(35)	<i>Bassia eriophora</i>	(10)
<i>Reboudia pinnata</i>	(35)	<i>Mesembryanthemum Forskahlei</i>	(10)
<i>Statice pruinosa</i>	(35)		

*Suaedetum palaestinae* is most conspicuous in the landscape owing to the dark glaucous tint of *Suaeda* which is a chamaephyte 30-50 cm. high with semicylindrical succulent leaves. Its very shallow many-branched roots spread horizontally and are limited to a depth of 10-30 cm. The

<sup>1</sup> We found 1,042% of Cl in the soil of the bright patches and 3,443% in the dark ones.

winter leaves are dropped in early summer and the short summer shoots bearing clusters of smaller leaves persist the whole summer. The osmotic values of the cell sap are as follows: max. 87,2; min. 36,2; average 64,8 atm.

(b) *Salsoletum Rosmarini*

This association is close to the *Suaedetum palaestinae* in its ecology and composition. The fact, however, that stands occur in which *Salsola Rosmarinus* is the only dominating chamaephyte and that most of these occupy a particular belt east of the *Suaedetum palaestinae* area (see map) has led us to separate this unit. Stands transitional between the two units also occur.

Typical habitats of this association are shallow wadis, furrowed flats and gullies. Examination of the salt-moisture relations in these habitats (see p. 180 and Figs. 3, 5, 6, 7) has shown that although the salt content of the soil is considerably higher than in *Suaedetum*, the concentration of the soil solution does not exceed that of *Suaedetum* because of the large amount of soil moisture. There is also no conspicuous fluctuation during the year. Accordingly, the osmotic values of the cell sap of the leading plant are lower and less fluctuating than those of *Suaeda palaestina* (max. 39; min. 27,5; average 33,5 atm.).

The floristic composition according to our 6 records is as follows:

<i>Salsola Rosmarinus</i>	(100)	<i>Suaeda fruticosa</i>	(50)
<i>Spergularia diandra</i>	(100)	<i>Suaeda palaestina</i>	(50)
<i>Plantago Coronopus</i>	(83)	<i>Salsola tetrandra</i>	(50)
<i>Schismus calycinus</i>	(83)	<sup>a</sup> <i>Torularia torulosa</i>	(50)
<i>Atriplex Halimus</i>	(66)	<i>Trigonella stellata</i>	(50)
<i>Centaura hyalolepis</i>	(66)	<i>Aaronsohnia Faktorovskii</i>	(33)
<i>Beta vulgaris</i>	(50)	<i>Aizoon hispanicum</i>	(33)
<i>Erucaria Boreana</i>	(50)	<i>Cistanche lutea</i>	(33)
<i>Malva parviflora</i>	(50)	<i>Pteranthus dichotomus</i>	(33)
<i>Plantago ovata</i>	(50)	<i>Salsola Austrani</i>	(33)
<i>Phalaris minor</i>	(50)	<i>Salsola vermiculata</i> ssp. <i>villosa</i>	(33)
<i>Reboudia pinnata</i>	(50)	<i>Sisymbrium Irio</i>	(33)
<i>Reichardia tingitana</i>	(50)	<i>Sphenopus diyaricatus</i>	(33)
<i>Spergularia marginata</i>	(50)		

It differs from *Suaedetum palaestinae* also by some negative characteristics, such as the absence of *Prosopis farcata*, *Alhagi Maurorum*, *Statice pruinosa*, etc.

*Salsola Rosmarinus*, the dominant chamaephyte of the association, reaches a height of 40-80 cm. Its green, linear succulent leaves drop at the end of winter and short summer shoots, appearing from their axils, bear only a few leaves.

(c) *Atriplicetum Halimi*, EIG, 1946

This association is the most complex unit of the area. The ten records collected comprise 95 species, but none is confined exclusively to this

association. And yet *Atriplicetum* is an autonomic community sufficiently defined by its physiognomy and the dominance of the leading species to which alone one must ascribe diagnostic value, other attributes being effaced by the wide ecological amplitude of *Atriplex*. This amplitude is manifested by the fact that it also enters almost all associations of the area. Its characteristic habitats, however, are deep ephemeral wadis of the "Broken Land" belt. While in the upper course of these wadis *Atriplex* is dominant it forms an outer zone along the *Tamaricetum* in their lower course. In the northern part of the area *Atriplicetum* occupies broad belts around depressions inhabited by *Suaedetum palaestinae* and around the cultivated land (Jericho, Auja, Far'a). Elsewhere it is most conspicuous at wadi outlets and in the outer belt of the Jordan flood zone.

Its salt-moisture demands can hardly be learned from standard sampling, since the exceedingly long roots of *Atriplex* presumably reach the ground-water table even in places where the latter is found at a depth of 10-20 m. On one occasion we succeeded in tracing a vertical root 8 m. but at that depth the root, still over 1 cm. thick, had sunk into the rock. It is also provided with horizontal subterranean shoots by the means of which it propagates vegetatively.

From its distribution it appears to us that *Atriplex* while requiring high soil moisture has a wide range of toleration to soil salinity but never to submerged soil.

All our records have been taken from wadis and depression borders. They all contain a fair amount of segetal and ruderal species since in the area reviewed the *Atriplicetum* is the most important centre of grazing for camels and sheep. The leaves of *Atriplex* are eaten by bedouins.

10 records were collected of this association and the following species may be regarded as typical representatives :

<i>Atriplex Halimus</i>	(100)	<i>Papaver Rhoeas</i>	(40)
<i>Crepis aspera</i>	(90)	<i>Pteranthus dichotomus</i>	(40)
<i>Mesembryanthemum nodiflorum</i>	(80)	<i>Reboudia pinnata</i>	(40)
<i>Spergularia diandra</i>	(70)	<i>Reichardia tingitana</i>	(40)
<i>Beta vulgaris</i>	(60)	<i>Salsola vermiculata</i> ssp. <i>villosa</i>	(40)
<i>Centaurea hyalolepis</i>	(60)	<i>Statice spicata</i>	(40)
<i>Koeleria phleoides</i>	(60)	<i>Astragalus callichrous</i>	(30)
<i>Malva parviflora</i>	(60)	<i>Avena barbata</i>	(30)
<i>Statice Thouinii</i>	(60)	<i>Cistanche lutea</i>	(30)
<i>Suaeda fruticosa</i>	(60)	<i>Echium judaeum</i>	(30)
<i>Suaeda palaestina</i>	(60)	<i>Plantago Lagopus</i>	(30)
<i>Chrysanthemum coronarium</i>	(50)	<i>Prosopis farcata</i>	(30)
<i>Lamarchea aurea</i>	(50)	<i>Sisymbrium Irio</i>	(30)
<i>Phalaris minor</i>	(50)	<i>Trisetum macrochaetum</i>	(30)
<i>Schismus calycinus</i>	(50)	<i>Aizoon hispanicum</i>	(20)
<i>Sphenopus divaricatus</i>	(50)	<i>Emex spinosus</i>	(20)
<i>Bromus scoparius</i>	(40)	<i>Medicago laciniata</i>	(20)
<i>Filago prostrata</i>	(40)	<i>Salsola tetrandra</i>	(20)
<i>Lolium rigidum</i>	(40)	<i>Cynomorium coccineum</i>	(10)

*Cistanche* and *Cynomorium* are root parasites of *Atriplex*. *Atriplex Halimus* is a shrub 1-2 m. high with broad greyish leaves covered with vesiculate water-storing hairs. Winter leaves are dropped early in summer and new short summer branches develop from their axils.

#### (4) *Tamaricion tetragynae* (Nos. 10—12)

This alliance is represented here by five associations:

(a) assoc. of *Arthrocnemum glaucum* — *Tamarix tetragyna*, (b) *Tamaricetum maris-mortui*, (c) *Suaedetum monoicae*, (d) *Nitrarietum retusa* and (e) *Suaedetum fruticosae*. All are limited to the Lower Terrace and foreshore of the Dead Sea and the Jordan River. They require a high amount of soil moisture. Most of them tolerate a high degree of salinity and temporary submersion of soil. They are rather common in the southern part of the area but are restricted to narrow belts. In order to obtain a clear picture of their composition, ecology and their interrelation this alliance should be studied along the southern edge of the Dead Sea. There the broad foreshore offers optimal conditions for development of the individual associations. With the exception of *Suaedetum fruticosae* the associations of this alliance are zonally arranged on the seasonally inundated, slightly sloping but more or less smooth foreshore. The main factor responsible for the zonation and their spatial sequence is no doubt the length of the inundation period and the degree of tolerance to submersion of the species.

The belting arrangement is less obvious on the narrow northern foreshore of the Dead Sea. It therefore often happens that one or more of the vegetational zones do not find proper conditions for development due to abrupt changes in topography.

Data on salt-moisture relation of the soil has been obtained for the *Arthrocnemum* — *Tamarix* association and for *Suaedetum fruticosae* (see pp. 180-188). It is clear that soil-moisture is here more decisive on zonation than is the degree of salinity.

Floristically this alliance is designated by a series of characteristic shrubs and trees not occurring or only occasionally reoccurring in other alliance of the area. These are *Suaeda monoica*, *Tamarix tetragyna*, *Tamarix maris-mortui*, *Nitraria retusa*, etc.

#### (a) Assoc. of *Arthrocnemum glaucum*—*Tamarix tetragyna* (No. 11) (Plate IV D)

This association, well represented in the area, is confined to depressions and wadis inundated for a certain time in winter. It also occurs on the foreshore of the Dead Sea. After the retreat of the water cover the soil remains moist almost throughout the whole year. In the degree of moisture and salinity there is no striking annual fluctuation. The following figures are rather characteristic of the habitat:

	max. %	min. %
soluble salts	9,556	5,012
Cl	3,838	1,822
moisture	23,6	14,5
concentration of soil solution	49,7	23,9

The association is very poor in annuals because of the extreme conditions of the habitat. The 11 records collected comprise 33 species, some of them accidentals. The following are typical representatives of the association :

<i>Arthrocnemum glaucum</i>	(100)	<i>Beta vulgaris</i>	(18)
<i>Suaeda fruticosa</i>	(54)	<i>Cistanche lutea</i>	(18)
<i>Tamarix maris-mortui</i>	(54)	<i>Lolium rigidum</i>	(18)
<i>Atriplex Halimus</i>	(45)	<i>Malva parviflora</i>	(18)
<i>Mesembryanthemum nodiflorum</i>	(36)	<i>Statice spicata</i>	(18)
<i>Phalaris minor</i>	(36)	<i>Trigonella stellata</i>	(18)
<i>Sphenopus divaricatus</i>	(27)	<i>Aeluropus littoralis</i>	(9)
<i>Suaeda palaestina</i>	(27)	<i>Frankenia pulverulenta</i>	(9)
<i>Tamarix tetragyna</i>	(27)	<i>Salicornia herbacea</i>	(9)
<i>Aaronsohnia Faktorovskyi</i>	(18)		

*Arthrocnemum* always has a high coverage, while all other plants are very sparsely represented. *Arthrocnemum* and *Tamarix* occupy the lower parts while the others are limited to more elevated spots. Often *T. tetragyna* is replaced by *T. maris-mortui*. *Arthrocnemum* is a leafless stem succulent, with a rather shallow root system. It flowers in summer. The osmotic values of the cell sap are as follows: max. 71,3; min. 50,4; average 60,2 atm. The *Tamarix* species have exceedingly long vertical and horizontal roots.

#### (b) *Tamaricetum maris-mortui*

Stands of this association are widely distributed in the southern part of the area (between Ras Feshkha and Jericho). They are confined to the lower outlet regions of the wadis and to inundated depressions. They are often zonally connected with the *Arthrocnemum* — *Tamarix tetragyna* association, forming pure stands or intermixed with *Suaeda monoica*.

The following is a sample record of *Tamaricetum* (mixed with *Suaeda monoica*) from about 150 m. W. of the Dead Sea shore, outpour of wadis, fine sandy, wet yellowish grey soil; area 100m.<sup>2</sup>, coverage 75%.

<i>Tamarix maris-mortui</i>	2—4	<i>Atriplex Halimus</i>	+-3
<i>Suaeda monoica</i>	2—4	<i>Suaeda palaestina</i>	+-2
<i>Suaeda fruticosa</i>	1—3		

The mixed nature of the stand is due to the unevenness of the surface permitting the entry of plants from adjacent drier zones.

#### (c) *Suaedetum monoicae*

This association occupies somewhat more elevated, but nonetheless periodically inundated spots within the *Arthrocnemum* — *Nitraria* zo-

nation complex. It is mainly limited to the vicinity of the Dead Sea foreshore and is very fragmentary here. Here is a sample record taken between Kallia and the Feshkha springs: undulated plain in the wadi outpour region, yellowish grey wet soil; area 100 m.<sup>2</sup>, coverage 50%.

<i>Suaeda monoica</i>	3 — 3	<i>Mesembryanthemum nodiflorum</i>	— + 1
<i>Suaeda fruticosa</i>	+ — 3		

*Suaeda monoica* is the only phanerophyte among the *Suaeda* species. It has linear succulent leaves and a long vertical root. In Wadi Araba this association occupies extensive areas (ZOHARY, 1945).

(d) *Nitrarietum retusae*, EIG, 1946

While in Wadi Araba this association covers large and continuous stretches of salines it never occurs here in considerable stands. Very often it fringes the *Arthrocnemum*—*Tamarix* association in wadis and depressions. It is also found on somewhat elevated ground within the zone of *Suaedion palaestinae*. On a slope ascending from an *Arthrocnemum* marsh we noted a stand growing on loose, greyish, saline wet soil, showing a coverage of 40%. Within the *Arthrocnemum*—*Nitraria* zonation complex *Nitraria* inhabits the outermost and most saline zone. In the surface soil we found about 13% and in a depth of 40 cm. about 8% of soluble salts.

(e) *Suaedetum fruticosae* (No. 12)

Although referred to the *Tamaricion* it is not always confined to the above zonation complex. It occupies a broad belt along the Jordan River at the outer edge of the *Populion* as well as on the elevated foreshore of the Dead Sea. *Suaeda* also penetrates into the *Suaedion* associations, notably into the *Atriplicetum*, as well as into other associations of the *Tamaricion*. In the above foreshores it is exposed to occasional or to very short submersion only. Near Beit-Haarava we found 1,85% of soluble salts and 0,657% of Cl at a depth of 15 cm.

As the soil of the *Suaedetum* is submerged only slightly, conditions permit the development of winter annuals and such as *Schanginia baccata*, *Rumex dentatus*, etc. are rather characteristic of this association. At least two sub-associations may be distinguished, the one confined to the outer zone of the Jordan terrace and the other to the foreshore of the Dead Sea. Of the ten records collected from this association six belong to the former and four to the latter. Here is a record of the sub-association *jordanis*: Jordan River, near Mathias, outer belt of the flood plain, plants crowded in patches alternating with sterile spots covered with salt efflorescence; area 100 m.<sup>2</sup>, coverage 70%.

<i>Suaeda fruticosa</i>	3 — 4	<i>Phalaris minor</i>	— + 1
<i>Schanginia baccata</i>	1 — 1	<i>Sisymbrium Irio</i>	— + 1
<i>Rumex dentatus</i>	2 — 1	<i>Lolium rigidum</i>	— + 1
<i>Aeluropus littoralis</i>	1 — 1	<i>Bromus scoparius</i>	— + 1

B



A

D



C



A



C

A: Association of *Andasis articulata*-*Notoceras bicorne*. Between the scattered shrubs — *Stipa tortilis*.  
 C: *Suadetum palestinae*. Lower Terrace between "Broken Land" and Dead Sea. The shrubs in front — *Atriplex Halimus*.

B: *Salsoletum tetrandrae*, on "Lissan Marl" of the Upper Terrace.  
 D: Association of *Anthrocnemum glutaceum* — *Tamarix tetragyna*, between Jericho and Allenby Bridge.



Where the soil is submerged for a longer period than usual, *Rumex*, a hydrophytic winter annual, and *Schaginia* a late spring annual dominate the plot. *Atriplex Halimus* and *Tamarix jordanis* very often penetrate this association from the adjacent *Populion*, the former sometimes a co-dominant. The sub-association *maris-mortui* is less exposed to inundation as it inhabits somewhat elevated plots outside the flooding range. On the other hand, its soil is more saline than that in the vicinity of the Jordan and annuals do not develop on it.

*Suaeda fruticosa* Forsk. is a shrub (chamaephyte), 70—120 cm. high, with cylindrical succulent leaves. It flowers in summer and its long flowering branches wither and die after fruiting. From the axils of the winter leaves dropping in early summer short vegetative summer shoots appear bearing smaller leaves.

#### (5) *Junceto — Phragmitition* (No. 13)

While this alliance is richly represented on the southern shore of the Dead Sea, it is fragmentary and rather rare in our area. It constitutes a zonation complex of its own, comprising several zonal associations, notably the *Phragmitetum communis* (*salinum*) and the *Juncetum arabicae*. It is confined to banks of rivulets, springs and other small water bodies permanently carrying saline or brackish water. It has not been studied adequately in this area, but the following record may be quoted: between Auja and Far'a, swamp, in the eastern edge of the great depression.

Zone 1, permanently submerged: *Phragmitetum communis*, consisting of pure *Phragmites* stands 2—2.

Zone 2, soil peaty and saline, slightly submerged: *Juncetum arabici*, consisting of *Juncus maritimus* var. *arabicus* 3—3, *Statice Limonium* 2—2, *Inula crithmoides* +—1, *Aeluropus littoralis* 1—1, *Suaeda fruticosa* 2—2, *Atriplex Halimus* +—3, *Schaginia baccata* +—1.

The latter 3 species no doubt constitute a third zone belonging to *Suaedetum fruticosae* which does not belong to the above complex. Changes in topography may sometimes disturb the regular sequence of the zones.

#### (6) *Populion euphratica*, EIG, 1946 (No. 14)

This alliance is confined to the flood zone of the Jordan River, which at that latitude contains a fair amount of chlorides (up to 1000mg. Cl per litre). The vegetation of this alliance constitutes a zonation complex of its own comprising a few plant associations arranged in accordance with configuration of the banks and topography of the flooded area. The most important associations are: *Populetum euphratica*, which occupies a belt closest to the River. Behind this belt *Tamaricetum jor-*

*danis* occurs in almost pure stands. Of the vegetation inhabiting the outer belts the association of *Prosopis farcata* — *Glycyrrhiza glabra* probably belonging to the *Prosopidion farcatae* may be mentioned. Records of these associations are given by EIG (1.c.). The ecological requirements of these associations have not yet been studied.

(7) *Nerion Oleandri*, ZOHARY, 1946.

The *Nerion Oleandri* is represented here by the *Viticetum Agnacasti* which is confined to gravelly, well-drained non-saline wadi beds. It covers considerable stretches in the upper course of Wadi Kelt (near Jericho).

(xii) *Depauperation and disappearance of plant communities*

It has already been stressed above that classification of zonal vegetation conditioned by edaphical factors calls for a special approach and method. In an ideal belting complex it is difficult to find a critical basis for delimitation of phytosociological units because there is no discontinuity between zones. Similar difficulties arise in cases where certain associations in the vicinity of abiotic deserts undergo gradual impoverishment of their floristical make-up leading to final disappearance of the association. In such extreme circumstances the association as a rule loses its leading perennials one by one, then the number of the annuals decreases gradually until a plantless desert results.

The occurrence of therophytic facies of certain associations is a common feature of deserts. In our area we have collected a series of records of such therophytic facies belonging to the *Salsola villosa* — *Stipa tortilis* association. Similarly we have noted such facies in the *Suaedetum palaestinae*, before this association is lost in the desert. We noted *Sphenopus divaricatus* 3—3, *Pteranthus dichotomus* +—1, *Mesembryanthemum nodiflorum* +—1, *Spergularia diandra* +—1, *Statice spicata* +—1, representing the *Suaedetum palaestinae* after *Suaeda* itself has disappeared.

Between the *Suaedetum palaestinae* of the Lower Terrace and the hydrohalophytic regimen of the Jordan River a belt of sterile bad lands (No. 15) is intercalated. Here large extents are plantless, except for runnels or furrows below surface level, supporting a few annual species. We examined such sterile soils near the Beth Haarava settlement and found that at a depth of 20cm. the soil of the plain contained 7,086%, while that of the runnels contained 1,418% soluble salts. The species found in the runnels are *Pteranthus dichotomus*, *Spergularia diandra*, *Mesembryanthemum nodiflorum*, etc.

Further eastwards one passes to an absolutely sterile desert containing up to 14% of soluble salts and about 5% of C1. The high salt content

would not in itself lead to absolute sterility were it not for the low amount of available water of the soil.

### (xiii) *Discussion and summary*

It was the aim of this investigation to delimit the vegetation units of the area, to reveal the obvious ecological factors involved in the phytosociological differentiation and to establish a map of vegetation.

As the climate factors operate more or less uniformly over the entire area it is the edaphic factors alone which affect the local vegetation. The salt-moisture-air relations of the soil are decisive for distribution of plant communities. The area has accordingly been subdivided into the following 6 habitats: (1) non-saline soils, (2) automorphic salines, (3) high water-table salines, (4) temporarily submerged salines, (5) permanently watered salines, (6) Jordan flood zone. Each of the above habitats supports a particular alliance of plant associations.

The non-saline soils form isolated areas, where the soil has been leached out by greater water courses or irrigation. The occurrence of a Sudano-Deccanian vegetation in these oases is in accordance to the ecological demand of this element in general. The oasis of Far'a is the northernmost large Sudano-Deccanian enclave of Palestine.

The automorphic salines are confined to the Upper Terrace. They are mainly inhabited by the associations of the *Salsolion villosae* which are xerohalophytic in that the relatively high amount of soluble salts in the soil is not compensated for by sufficient moisture. The leading plants of these associations have to overcome both drought and salinity and this is done by highly developed root systems or high osmotic values or by both.

The high water table salines exhibit at least seasonally a fair amount of moisture due to rise of the underground water table, but are never submerged. They are mainly confined to the Lower Terrace and inhabited by the *Atripliceto-Suaedion*. The high soluble salt content is compensated at least in winter by higher moisture content: the leading plants are either shallow-rooted, with high osmotic values, or extremely deep-rooted, with lower osmotic values.

The *Suaedion* and *Salsolion* form the major vegetation cover of the area. Within each alliance the associations are distributed according to gross topography, depth of the soil layer, salinity, etc. While these alliances never form typical zonation complexes, the alliances of the following three habitats constitute closed unilateral or concentric zonation complexes. As the regular zonal arrangement within these complexes is sometimes effaced by topographical irregularities the individual zones are not always clear-cut.

The seasonally submerged soil is confined to badly drained wadis and depressions in which water is accumulated during a part of the winter. *Tamaricion tetragynae* comprising here 5 zonal associations mainly occupies this habitat. With the exception of *Arthrocnemum* all leading species of the associations are deep-rooted shrubs or trees. All exhibit rather high osmotic values of cell sap. But the seasonal fluctuations of these values are not considerable as compared with those of plants of drier habitats.

The permanently submerged soils are spatially very limited and have not been adequately studied. It is mainly a reed-rush vegetation (*Junceto-Phragmition*) that occupies flats and hollows near springs and rivulets carrying brackish or saline water.

The flood zone of the Jordan bears a riparian forest of *Populus* and *Tamarix* arranged in zones. This thicket is the most attractive feature of the desert area. The soil of the flooded zone is rather saline due to the considerable amount of chlorides in the water of the river.

From the occurrence of so great a number of phytosociological units in a rather limited area it is obvious that the halophytic vegetation is much more susceptible to variations of edaphic factors than the hydrophytic vegetation, since plant life is influenced here not merely by the absolute values of salt and moisture but also by the endless quantitative combinations of both factors.

As in the hydrophytic vegetation delimitation of individual plant associations within the halophytic zonation complex is most difficult. The question whether each zone of the complex is to be ranked with an association is less important than whether one may split such natural complexes. At all events conventional phytosociological methods are inadequate for analytical treatment of such vegetation complexes.

At this juncture we wish to mention also the question of characteristic species (BRAUN-BLANQUET, 1928) as a valuable attribute in the definition of the association concept. Plant sociology was developed and its methods elaborated in humid or temperate regions. Very little phytosociology has as yet been practiced in deserts. Experience has shown that when referred to desert vegetation the definition of the association must be modified, at least as concerns characteristics. Even in well defined associations one looks in vain for characteristic species. Analytical tables of dozens of associations in desert zones prepared in order to pick out "characteristics" proved unproductive. In many plant associations one finds a single dominant species belonging to a higher life form together with a swarm of eurysynusial therophytes, confined to the rainy season only. In this season the differences between many habitats are so weakened as to allow the occurrence of an identical annual

flora in various plant associations and even in various alliances. Besides, annual associates fully developed in certain years may be altogether or partly lacking in rainless years, while perennials are permanently bound to the habitat. Moreover, the annual associates are not uniformly dispersed within the stand — they occupy especially favoured spots, such as depressions, runnels, etc. and seem to constitute within the association a unit of their own. These and other factors clearly show how slight is the coherence between associates in desert vegetation and how loose the structure of the association.

It follows from the above that, in regions subjected to adverse conditions, phytosociological analysis must often be based on quantitative characteristics, such as dominance and presence of the leading plants, belonging to higher life forms, which alone reflect the conditions of the habitat.

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# STUDIES IN THE ECOLOGY OF NECTAR SECRETION

By A. FAHN

(With 28 figures in the text)

The investigation described in this study was carried out in Palestine in 1944—1947 in the Upper Jordan Valley, in Jerusalem and Mikveh Israel; a few data from Tel-Aviv and Pardess Hannah are also included. The meteorological data were obtained from Beth Gordon in Degania A and from the Meteorological Institute, Hebrew University.

## (i) METHOD

For the determination of quantities of nectar production we chose the technique of BEUTLER (1930) as the most efficient of methods. However, in the course of the study it became apparent that even this technique was inaccurate, and a special type of pipette was devised to permit maximum withdrawal of nectar from the flower and to weigh the nectar directly without transfer to a weighing dish and without sealing the tip in a flame, as was done by PERCIVAL (1946). This method was also time-saving.

The pipette (Fig. 1) consisted of a narrow glass tube communicating with a bulb (c) 1 cm. in diameter. The tubular portion of the pipette (d) was 2.5 mm. in diameter and was bent into a double U with its upper elbow extended just beyond the upper surface of the bulb. The length of the descending portion (b) was adapted to the maximal depth of the flowers examined and its end drawn out into a capillary point (a). The nectar was withdrawn with the aid of a rubber tube attached to the pipette at (d) and was collected in the bulb (c). The elbow (e) between the tube and the bulb aided in retaining the nectar within the pipette, which was of known weight. Following complete withdrawal of the nectar the pipette was weighed on a precise torsion balance, on whose hook it was suspended at its elbow (e). The pipettes were also suspended by the elbow on drying racks in the same manner, and a similar arrangement permitted convenient transport from the field to the laboratory. Special boxes were made for storing the racks.

In each case the nectar was weighed both fresh and after drying to a constant weight at 80°C. Before the withdrawal of its nectar the flower was screened to prevent access of insects. In certain cases flowers were covered with test tubes to prevent evaporation of the nectar.

## (ii) DETERMINATION OF FRESH AND DRY WEIGHTS OF NECTAR COLLECTED FROM PALESTINIAN PLANTS

Daily nectar secretion of 66 species of wild and cultivated plants was determined. Data representing average values from numerous determinations are given in Table 1.

TABLE 1. Quantities of nectar produced per flower per day

Name of plant	Fresh nectar in mg.	Dry nectar in mg.	% concentr. of nectar
<i>Abutilon pictum</i> Walp.	116,83	47,36	40,5
<i>Antirrhinum majus</i> L.	3,24	1,47	45,3
<i>Asphodeline lutea</i> L.	5,25	3,50	66,6
<i>Asphodelus microcarpus</i> Viv.	4,15	2,62	63,1
<i>Bauhinia purpurea</i> L.	9,29	3,16	34,0
<i>Bryonia multiflora</i> Boiss. et Heldr.	0,75	—	—
<i>Caesalpinia Gilliesii</i> Wall.	44,62	18,62	41,7
<i>Callistemon lanceolatus</i> DC.	18,08	4,50	24,8
<i>Capparis sicula</i> Duham.	99,90	27,00	27,0
<i>Capparis spinosa</i> L.	32,75	12,00	36,6
<i>Centaurea hyalolepis</i> Boiss.	0,20	0,07	35,0
<i>Ceratonia Siliqua</i> L.	2,32	0,43	18,5
<i>Citrus Aurantium</i> L. — Bergamot	35,25	12,37	35,0
<i>Citrus Aurantium</i> L. — Khushkhash	23,66	6,08	25,8
<i>Citrus Limon</i> L. — Commune	27,00	7,75	28,6
<i>Citrus Limon</i> L. — Eureka	25,26	6,30	24,9
<i>Citrus Limon</i> L. — Villafranca	17,9	5,15	28,7
<i>Citrus Medica</i> L. — Etrog	13,41	8,08	60,2
<i>Citrus paradisi</i> Macf.	30,72	7,80	25,4
<i>Citrus reticulata</i> Blanco — Clementine	9,08	4,16	42,5
<i>Citrus sinensis</i> L. — Bizeri	23,66	2,75	11,6
<i>Citrus sinensis</i> L. — Navel	23,70	5,28	22,2
<i>Citrus sinensis</i> L. — Shamouti	20,22	5,84	28,9
<i>Citrus sinensis</i> L. — Valencia	61,50	24,00	39,0
<i>Citrus sinensis</i> L. — Washington	25,31	7,43	29,3
<i>Colchicum</i> Ritchii R. Br.	17,00	2,41	14,1
<i>Convolvulus arvensis</i> L.	4,00	—	—
<i>Cotoneaster horizontalis</i> Decne.	2,93	1,45	49,4
<i>Cotoneaster pannosa</i> Franch.	0,75	0,25	33,3
<i>Crataegus Azarolus</i> L.	0,75	0,31	41,3
<i>Cucumis sativus</i> L.	3,25	1,00	30,7
<i>Cucurbita maxima</i> Duch.	201,25	32,37	16,0
<i>Cucurbita Pepo</i> L.	98,40	27,60	28,0
<i>Eucalyptus rostrata</i> Schlecht.	5,70	1,25	21,9
<i>Helianthus annuus</i> L.	0,20	0,12	60,0
<i>Hibiscus Rosa-sinensis</i> L.	108,82	22,25	20,4
<i>Ipomoea purpurea</i> Lam.	19,25	8,00	41,4
<i>Jasminum primulinum</i> Hemsl.	1,00	0,33	33,0
<i>Lavatera punctata</i> All.	7,25	4,25	58,6
<i>Molucella laevis</i> L.	2,30	0,60	26,0
<i>Musa paradisiaca</i> L. var. <i>sapientum</i> Kuntze	267,75	74,37	27,4
<i>Oenothera Drummondii</i> Hook.	26,57	6,05	22,6
<i>Oxalis cernua</i> Thunb.	0,66	0,50	75,7
<i>Passiflora coerulea</i> L.	81,75	42,00	52,5
<i>Pelargonium graveolens</i> L'Her.	0,81	0,58	71,6
<i>Pittosporum undulatum</i> Vent.	0,50	0,41	82,0
<i>Pirus communis</i> L.	0,16	—	—
<i>Pirus Malus</i> L. — Astrakhan	1,57	1,37	87,2
<i>Pirus Malus</i> L. — Grand Alexander	0,35	0,28	80,0
<i>Pirus Malus</i> L. — Kaiser	1,09	0,82	75,2
<i>Prunus domestica</i> L.	0,37	0,25	67,5
<i>Poinciana regia</i> Bojer	1,25	0,50	40,0
<i>Poncirus trifoliata</i> Raf.	2,30	0,86	37,3
<i>Prosopis farcata</i> (Banks et Sol.) Eig	0,28	0,21	75,0
<i>Punica Granatum</i> L.	23,55	10,93	46,4

Name of plant	Fresh nectar in mg.	Dry nectar in mg.	% concentr. of nectar
<i>Rosmarinus officinalis</i> L.	0,80	0,50	62,5
<i>Salvia farinacea</i> Benth.	0,50	0,33	66,0
<i>Salvia leucantha</i> Cav.	11,96	4,38	36,6
<i>Salvia triloba</i> L. fil.	1,44	0,63	43,7
<i>Satureja Thymbra</i> L.	1,00	0,85	85,0
<i>Styrax officinalis</i> L.	1,34	1,06	79,1
<i>Tecoma stans</i> Juss.	8,25	3,50	42,4
<i>Tecomaria capensis</i> Seem.	45,16	9,00	20,0
<i>Thevetia neriifolia</i> Juss.	48,50	17,50	36,0
<i>Thymus capitatus</i> (L.) Lk. et Hoffm.	0,13	0,09	69,2
<i>Vitex Agnus-castus</i> L.	0,60	0,30	50,0

The following conclusions may be drawn from Table 1 as well as from data on nectar production in other countries (see references):

(a) Nectar production varies in different plants. The highest daily nectar production examined by us was in *Musa paradisiaca* var. *sapientum* which secreted a daily average of 267.75 mg. of fresh nectar (dry weight of 74.37 mg.). The daily secretion of a male flower of this plant reaches 590.75 mg. fresh nectar (dry weight of 190 mg.).

The lowest observed daily secretion was in *Thymus capitatus* (0.13 mg. fresh-, 0.10 mg. dry-weight). Many plants produce even considerably smaller quantities, but these cannot be measured by weighing.

Nectar secretion varies widely not only between different families, but even in different species of the same family or subfamily. Compare for example *Cucurbita maxima* with *Bryonia multiflora*; *Abutilon*



Fig. 1. The pipette employed for the removal of nectar from the flowers.

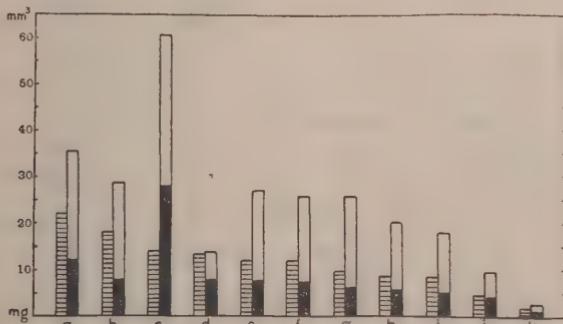


Fig. 2. Volume of nectar-producing tissue and quantities of nectar secreted by various species and strains of *Citrea*. a = *Citrus Aurantium* — Bergamot; b = *C. paradisi*; c = *C. sinensis* — Valencia; d = *C. Medica* — Etrog; e = *C. Limon* — Commune; f = *C. sinensis* — Washington; g = *C. Limon* — Eureka; h = *C. sinensis* — Shamouti; i = *C. Limon* — Villafranca; j = *C. reticulata* — Clementine; k = *Poncirus trifoliata*. The volume of the nectary is represented by bars with horizontal hatching. The black bars represent the dry weight and the white bars the water content of the nectar.

*pictum* with *Lavatera punctata*; *Caesalpinia Gilliesii* with *Poinciana regia* (Table 1). Also closely related genera, species and varieties differ greatly in this regard (e. g. *Citrus sinensis* — Valencia and *Poncirus trifoliata*; *Salvia leucantha* and *Salvia farinacea*; *Citrus Aurantium* L. — Bergamot and *Citrus reticulata* Blanco — Clementine; apple varieties: Astrakhan and Grand Alexander).

(b) A definite correlation appears to exist between the quantity of nectar and the volume of the nectar-producing tissue. In the tribe *Citreae* in which the nectaries of the different species resemble one another in structure the association of the quantity of nectar with the volume of the nectar-producing tissue was demonstrated in 11 species and strains (Fig. 2).

In the Valencia orange a slight deviation from the above has been noted, possibly due to the rather small number of flowers examined.

### (iii) CONCENTRATION OF THE NECTAR

Dried nectar consists chiefly of sugar, as demonstrated by BEUTLER (1930) and confirmed in the present study. The sugars composing it are saccharose, glucose and fructose; they are found in different plants in varying proportions (Table 2).

TABLE 2. Respective quantities of sugars in nectar  
(expressed as percentages of fresh weight)

Name of plant	Dry matter	Reducing sugars	Non-reducing sugars taken as saccharose
<i>Abutilon pictum</i> Walp.	49,1	36,9	5,14
<i>Asphodelus microcarpus</i> Viv.	—	61,5	23,0
<i>Ceratonia Siliqua</i> L.	—	10,8	0,0
<i>Citrus Limon</i> L. — Commune	33,2	12,1	17,6
<i>Citrus Limon</i> L. — Eureka	30,4	12,8	6,8
<i>Citrus Medica</i> L.	27,4	6,6	17,7
<i>Citrus paradisi</i> Macf.	29,2	15,2	9,6
<i>Citrus reticulata</i> Blanco — Clementine	—	25,2	2,9
<i>Citrus sinensis</i> L. — Ruby	22,2	16,0	3,1
<i>Citrus sinensis</i> L. — Shamouti	21,2	13,4	5,0
<i>Citrus sinensis</i> L. — Valencia	16,7	13,2	2,2
<i>Citrus sinensis</i> L. — Washington	22,7	12,9	7,9
<i>Colchicum</i> Ritchii R. Br.	14,2	14,3	0,0
<i>Lavandula dentata</i> L.	—	—	43,7
<i>Musa paradisiaca</i> var. <i>sapientum</i> L.	18,8	11,6	3,57
<i>Rosmarinus officinalis</i> L.	15,2	7,6	8,2
<i>Salvia Greggii</i> Gray	—	3,9	20,8
<i>Tecomaria capensis</i> Seem.	—	18,8	0,63

Nectar concentrations varied over a wide range (8 to 70%) in the 17 plants examined by BEUTLER (1930). In Palestinian plants they varied even more widely (Table 1) although the minimum was higher.

The degree of concentration depends neither on the systematic position of a plant nor on the anatomical structure of the nectary, nor on the structure of the flower or the position of the nectary within the flower (compare concentrations in Bizeri orange, 11.6% and Jewish citron 60.2%). Nor is there a difference in this regard between exposed and concealed nectaries. Thus, for example, low concentrations were observed both in *Tecomaria capensis* with a concealed nectary, and in *Colchicum Ritchii* and *Cucurbita maxima* with more or less exposed nectaries; whereas, on the other hand, nectar concentrations are high in *Satureja Thymbra*, *Thymus capitatus* and *Pelargonium graveolens* all with concealed nectaries, and in apples, whose nectaries are exposed.

#### (iv) EFFECT OF HUMIDITY ON NECTAR CONCENTRATION

##### (1) Variations in nectar concentrations in the same flower at different times of day

Figs. 3b, 4 and 5b demonstrate the definitely inverse relationship between nectar concentrations in a flower of *Hibiscus Rosa-sinensis*, *Citrus Limon*, *Thevetia nereifolia* at varying times of day and the respective relative atmospheric humidities. The same was found in

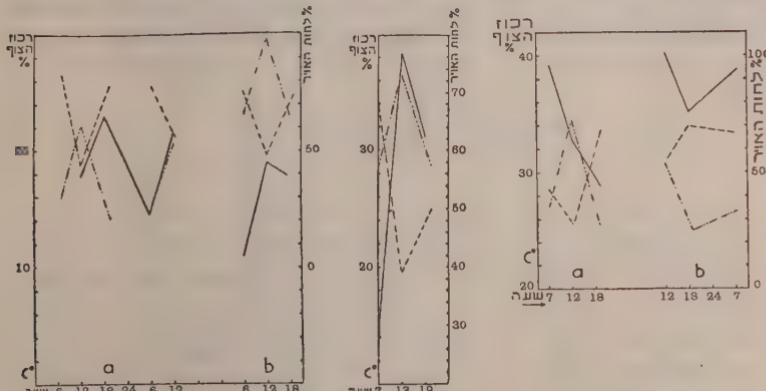


Fig. 3. The influence of atmospheric humidity on nectar concentration in *Hibiscus Rosa-sinensis* at varying times of day; a: 11/12.4.45; b: 22.5.1945;  
 — nectar concentration  
 - - - % atmospheric humidity  
 - · - - - temperature.

Data from Degania A.

(Ordinates: left: temperature and % of nectar concentration, right: % of atmospheric humidity; abscissae: hours.)

Fig. 4. The influence of atmospheric humidity on nectar concentration in *Citrus Limon* at varying times of day; legend as in Fig. 3. Data from Kinereth, 27.6.1945.

Fig. 5. The influence of atmospheric humidity on nectar concentration in *Thevetia nereifolia* at varying times of day; a: 30.5.1945, b: 7/8.6.45; legend as in Fig. 3. Data from Degania A.

*Tecomaria capensis* and other plants. This is, however, not always the case. In *Hibiscus Rosa-sinensis* inverse relationship between nectar concentration and atmospheric humidity was observed (as demonstrated in Fig. 3 a) only in the advanced age of the flower, and not soon after its opening. Similar results were obtained with *Thevetia nereifolia* and are presented in Fig. 5a.

Since the discrepancies between the nectar concentration and humidity curves occur when secretion begins, at a time identical in this case with the early opening of the flower, it may be assumed that in addition to humidity and other external factors, internal factors, such as rhythm of secretion, may be at play and overshadow the humidity factor early in the opening of the flower. This assumption is supported by the fact that the directions of the curves are identical in both cases: in those where the inverse relationship between humidity and concentration does exist, and in those in which it does not exist.

#### (2) Variations in nectar concentration in the same flower, in different flowers and on different days

The relationship between atmospheric humidity and nectar concentration is further demonstrated in Figs. 6, 7, 8 for the Shamouti orange, the Eureka lemon, *Abutilon pictum* and *Tecomaria capensis*.

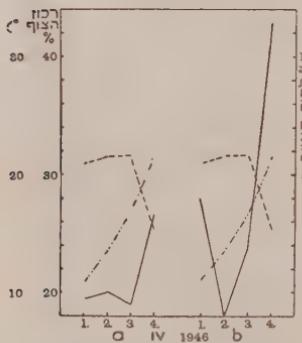


Fig. 6. The influence of atmospheric humidity on nectar concentration during the life of a single flower; a: Shamouti orange, b: Eureka lemon; — concentration of nectar from the same flower on successive days, — — — % atmospheric humidity. Data from Mikveh Israel. (Ordinates as in Fig. 3.)

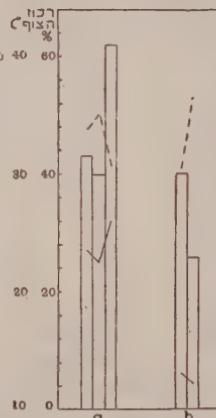


Fig. 7. The influence of atmospheric humidity on nectar concentration during the life of a single flower of *Abutilon pictum*. a: 18.-19.-20.9.46, b: 4.-5.-12.46; bar graphs represent concentrations of nectar from the same flower on successive days; — temperature, — — — % atmospheric humidity. Data from Jerusalem, Mount Scopus.

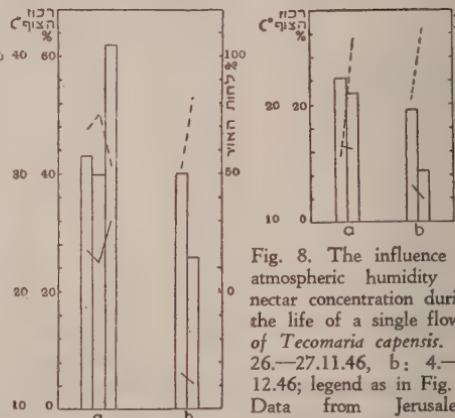
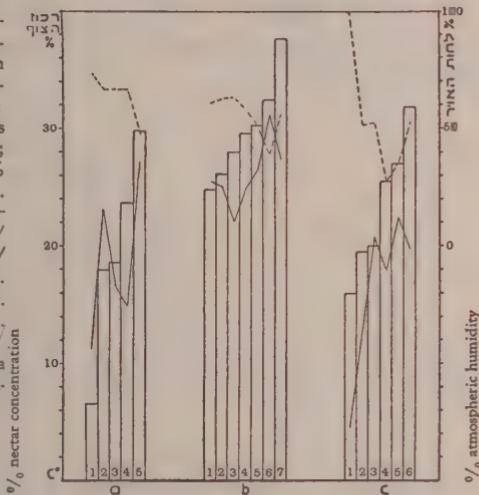


Fig. 8. The influence of atmospheric humidity on nectar concentration during the life of a single flower of *Tecomaria capensis*. a: 26.-27.11.46, b: 4.-5.-12.46; legend as in Fig. 7. Data from Jerusalem, Mount Scopus.

The effect of humidity on nectar concentration is most clearly brought out in the case of the flower of *Abutilon pictum* whose nectar concentration reached 87% on 19.5.46, the third day of a khamsin. In flowers with unexposed nectaries, such as *Tecomaria capensis*, such a condition did not occur. The same conclusion on the influence of atmospheric humidity on nectar concentration is to be drawn from Fig. 9, which represents variations in the concentrations of nectar samples taken on different days from various flowers of the same plant.

Fig. 9. The influence of atmospheric humidity on nectar concentration in different flowers and on different days; a: *Hibiscus Rosasinensis*, b: *Capparis sicula*, c: *Tecomaria capensis*; bar graphs represent nectar concentrations; — temperature, — atmospheric humidity. a: 1—6.2. 45, 2—22.5.45, 3—11.4.45, 4—12.4.45, 5—30.5.45; b: 1—23/24.5.45, 2—14/15.5.44, 3—31.5/1.6.44, 4—15/16.5.44, 5—24/25.5.45, 6—27/28.5.45, 7—18/19.6.45; c: 1—23.1.47, 2—4.12.46, 3—1.11.46, 4—26.11.46, 5—4.11.46, 6—7.11.46. Data: a and b — Degania A, c — Jerusalem, Mount Scopus.



### (3) Nectar concentration and exposure of the nectaries

It has been shown above that the concentration of freshly secreted nectar does not depend on the degree of exposure of the nectary. However, the concentration of the stored nectar is more directly influenced in exposed than in unexposed nectaries. This view, first formulated by SPRENGEL (1793) and supported by BEUTLER (1930) and PARK (1929), is further borne out by the data in Figs. 3 and 9. We may recall the case of the lemon, with the exposed nectary, in which nectar concentrations vary much more widely than in plants whose nectaries are less exposed.

In *Eucalyptus* with nectaries in the forms of a saucer secreting a moderate quantity of nectar, it was found that external conditions immediately influence each batch of nectar secreted. Thus it was rarely feasible to withdraw unchanged nectar from its flowers without first enclosing them in test tubes rather than in the usual screen, to create a humid atmosphere artificially.

## (v) INFLUENCE OF TEMPERATURE ON QUANTITY OF NECTAR PRODUCED

In general our results support the views of BONNIER (1878), ZANDER (1927) and OSTASHENKO-KOODYAVZEEVA (1928).

Fig. 10 shows for *Hibiscus Rosa-sinensis*, *Abutilon pictum* and *Capparis sicula* that an increase in the temperature is accompanied by an increase in the dry weight of the nectar. In *Tecomaria capensis*, as presented in Fig. 11, part of graph (data from Mt. Scopus, Jerusalem) parallels the results in Fig. 10, whereas other portions disagree with these results. Graph b in Fig. 11 (data from Degania A) shows clearly that a drop in temperature is accompanied by a rise in the dry weight of nectar.

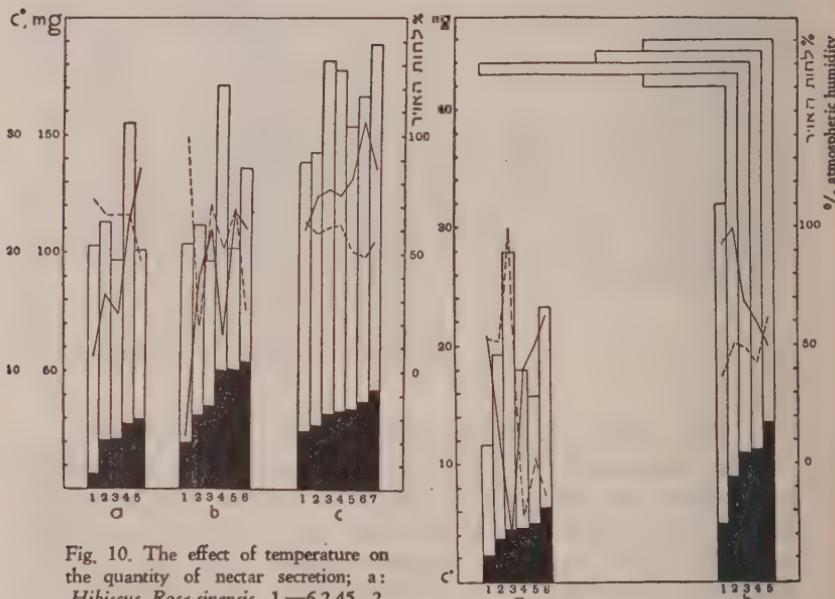


Fig. 10. The effect of temperature on the quantity of nectar secretion; a: *Hibiscus Rosa-sinensis*, 1—6.2.45, 2—11.4.45, 3—12.4.45, 4—22.5.45, 5—30.5.45; b: *Abutilon pictum*, 1—23.1.47, 2—6.5.46, 3—17.9.46, 4—4.12.46, 5—18.9.46, 6—7.6.46; c: *Capparis sicula*, 1—31.5./1.6.44, 2—15./16.5.44, 3—23./24.5.45, 4—14./15.5.44, 5—24./25.5.45, 6—27./28.5.45, 7—18./19.6.45; black areas in bar graphs represent dry weight, dry weight, white areas water content of nectar; —— temperature, —— % atmospheric humidity.  
// Data: a and c Degania A, b — Jerusalem, Mount Scopus.

Fig. 11. The effect of temperature on the quantity of nectar secretion in *Tecomaria capensis*; a: 1—1.11.46, 2—4.12.46, 3—23.1.47, 4—26.11.46, 5—7.11.46, 6—4.11.46; b: 1—29.5.45, 2—20.6.45, 3—3.5.45, 4—30.4.45, 5—2.5.45; legend as in Fig. 10. Data: a — Jerusalem, Mount Scopus, b — Degania A.

## (vi) SOIL HUMIDITY AND QUANTITY OF NECTAR

A number of experiments were carried out with *Centaurea hyalolepis*, *Punica Granatum* and *Antirrhinum majus*.

Experiment 1: A single specimen of *Centaurea hyalolepis* (Fig. 12) was watered and the quantity of nectar was measured one and two days thereafter. Nectar production by a nearby unwatered specimen was also measured on the same days as a control. The average nectar production by a single flower was calculated from measurements of all of the 30 to 40 flowerets in a headlet.

Results: On the day after watering no difference was observed in the quantity of nectar produced by the watered as compared with the unwatered plant. Two days after watering a significant difference was found (unwatered: 0.14 mg. fresh nectar and 0.014 mg. dry weight per flower; watered: 0.4 mg. fresh nectar and 0.13 mg. dry weight per flower).

These data demonstrate that soil humidity has a marked effect on the quantity and dry weight of the nectar produced in *Centaurea hyalolepis*. This effect does not occur until two days after watering.

Experiment 2 was carried out on two trees of *Punica Granatum*, Fig. 13, one of which had not been watered for the two weeks preceding the experiment, while the second had been watered until the day of measurement.

Results: A single flower of the unwatered tree produced an average of 27.3 mg. fresh nectar with a dry weight of 13.5 mg., whereas in the watered tree the respective figures of 33.75 mg. and 14.25 mg. were obtained.

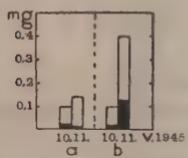


Fig. 12. Influence of soil humidity on the quantity of nectar production by *Centaurea hyalolepis*; a: unwatered plant, b: plant watered on 9.5.45; black areas in bar graphs represent dry weight, white areas water content of nectar. Data from Degania A.

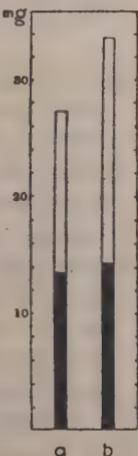


Fig. 13. Influence of soil humidity on the quantity of nectar production by *Punica Granatum*; legend as in Fig. 12. Data from Degania A, 24.5.45.

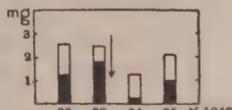


Fig. 14. Influence of soil humidity on the quantity of nectar production by *Antirrhinum majus*; legend as in Fig. 12, the arrow marks the re-watering of the plant after it had wilted. Data from Jerusalem.

Experiment 3: was carried out with *Antirrhinum majus*, Fig. 14 grown in pots. Water was withheld during two days until the plant began to droop; nectar production was measured daily during this period. The plant was then watered and nectar production measured on the following day.

Results: On the first day the average nectar production per flower was 2.6 mg. of fresh nectar with a dry weight of 1.25 mg. On the second day the respective quantities were 2.5 mg. and 1.8 mg. On this day the leaves had begun to wilt and only the flowers still remained fresh. The plant was re-watered after that and on the following day the leaves had recovered, but the average quantity of nectar per flower had dropped to 1.25 mg. of fresh nectar (dry weight of 0.25 mg.). By the second day after watering nectar production per flower had risen again to 2.1 mg. of fresh nectar (dry weight of 1 mg.).

In general these results support the view of BONNIER (1879) and of OSTASHENKO-KOODYAVZEEVA (1928) that soil humidity has a positive effect on the quantity of nectar secretion; they do not bear out the views of BEUTLER (1930). Our data on *Centaurea* and *Antirrhinum* also agree with BONNIER's conclusion that soil humidity acts after several days' delay rather than immediately.

#### (vii) DAILY RHYTHM IN THE QUANTITY OF NECTAR SECRETION

The daily rhythm of nectar secretion was studied on the same flower at 6-hour intervals in the following species:

In *Hibiscus Rosa-sinensis* (Fig. 15) the dry weight peak was observed at midday (nectar produced between 6 a.m. and noon). Sometimes, as on cool days in February and April, this peak was observed in nectar collected in the evening.

In *Tecomaria capensis* (Fig. 16), *Theretra nereifolia* (Fig. 17) and *Citrus Limon* (Fig. 18) the dry weight peak occurred during the morning hours. In *Tecomaria* it was observed once in the early morning. The first two diagrams of Fig. 18 show that nocturnal secretion is low and practically ceases during the second half of the night.

In *Citrus reticulata* (Fig. 19) dry weight peaks occurred in the morning and afternoon. Secretion ceased at night. In *Punica Granatum* (Fig. 20) dry weight peaks occurred in the morning and afternoon. The maximal quantity was found soon after the opening of the flower. Initial secretion may thus take place in the unopened flower.

In *Capparis sicula* (Fig. 21) the flowers always open late in the afternoon and generally wither by the following noon. Maximum secretion occurs during the second half of the night.

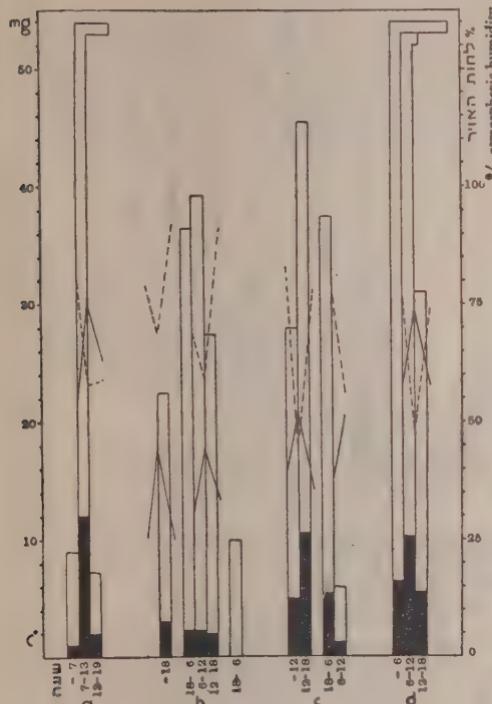


Fig. 15. Daily rhythm in the quantity of nectar secretion in *Hibiscus Rosa-sinensis*; a: 5.6.44; b: 5.7.2.45; c: 11.12.4.45; d: 22.5.45; legend as in Fig. 10. Data from Degania A.

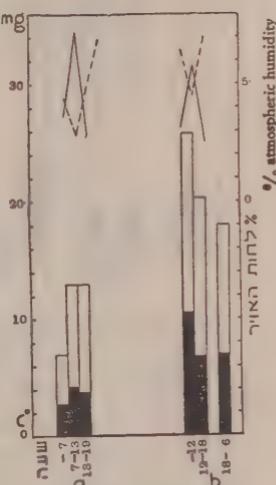


Fig. 16. Daily rhythm in the quantity of nectar secretion in *Tecomaria capensis*; a: 30.4.45; b: 3.5.45; c: 29.5.45; d: 20.6.45; legend as in Fig. 10. Data from Degania A.

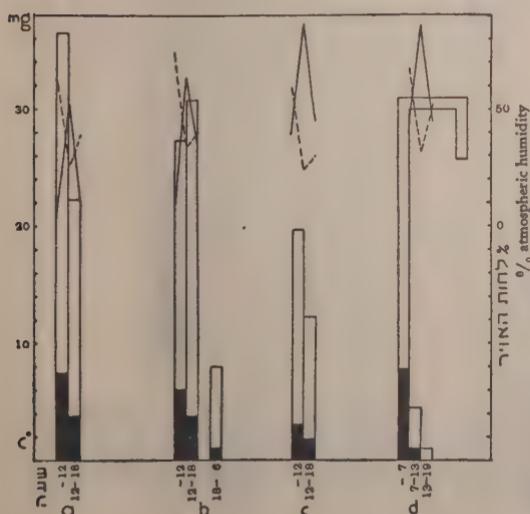


Fig. 17. Daily rhythm in the quantity of nectar secretion in *Thespesia nereifolia*; a: 30.5.45; b: 7.8.6.45; legend as in Fig. 10. Data from Degania A.

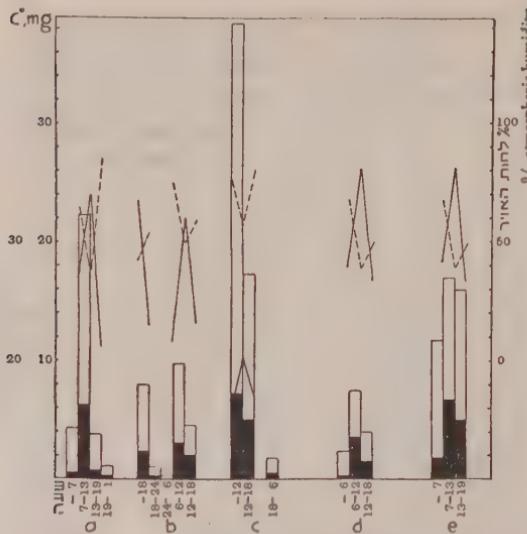


Fig. 18. Daily rhythm in the quantity of nectar secretion in *Citrus Limon*; a: 11./12.5.44; b: 13./14.5.44; c: 12./13.4.45; d: 27.6.45; e: 27.6.45; legend as in Fig. 10. Data from Degania A.

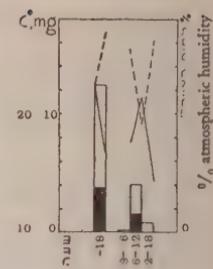


Fig. 19. Daily rhythm in the quantity of nectar secretion in Mandarine (*Citrus reticulata*); legend as in Fig. 10. Data from Kinereth, 9./10.4.45.

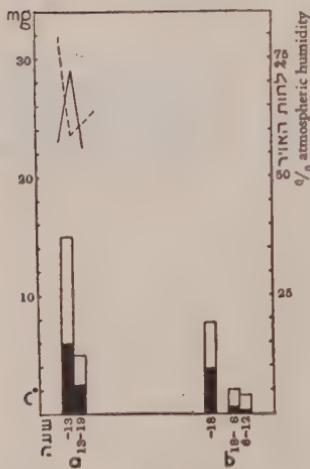


Fig. 20. Daily rhythm in the quantity of nectar secretion in *Punica Granatum*; a: 19./20.5.44; b: 20./21.5.44; legend as in Fig. 10. Data from Degania A.

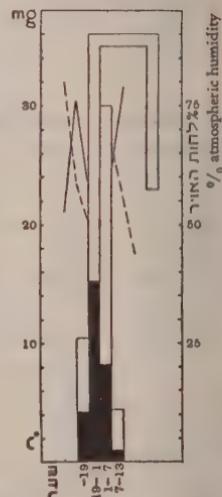


Fig. 21. Daily rhythm in the quantity of nectar secretion in *Capparis sicula*; legend as in Fig. 10. Data from Degania A, 15./16.5.44.

In *Oenothera Drummondii* (Fig. 22) the flowers open in the evening and maximum secretion, particularly dry weight peaks occur during the afternoon before the flower opens. During the first half of the night secretion is less marked and dry weight minima, sometimes approaching 0, were observed in the second half of the night.



Fig. 22. Daily rhythm in the quantity of nectar secretion in *Oenothera Drummondii*. 1: till 6 p.m.; 2: 6 p.m. — 12 p.m.; 3: 12 p.m. — 6 a.m.; legend as in Fig. 10. Data from Tel-Aviv, 1/2.10.46.

#### (viii) QUANTITIES OF NECTAR SECRETED DURING THE LIFETIMES OF VARIOUS FLOWERS

Quantities of nectar secreted during the lifetime of flowers were studied in the following plants: *Callistemon lanceolatus*, Eureka lemon, Navel, Shamouti and Bergamot oranges, and *Poncirus trifoliata*. All data in Figs. 23-25 are based on average values for several flowers.

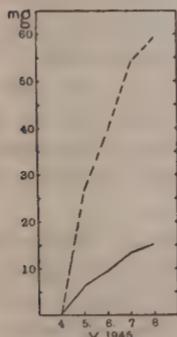


Fig. 23. Quantity of nectar produced during the lifetime of a single flower of *Callistemon lanceolatum*; —— fresh nectar, —— dry weight. Data from Kinereth.

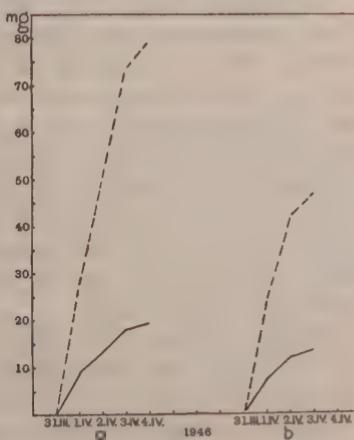


Fig. 24. Quantities of nectar produced during the lifetime of a single flower of: a — Eureka lemon, b — Navel orange; legend as in Fig. 23. Data from Mikveh Israel.

In *Callistemon lanceolatus* (Fig. 23) the dry weight of the total nectar secreted during the lifetime (4.5 days) of a flower is 15.25 mg. The maximum secretion occurs on the first, the minimum on the last day. The same was observed in Eureka lemon (Fig. 24a) in which the dry weight of the total nectar secreted by a flower is 20.75 mg.

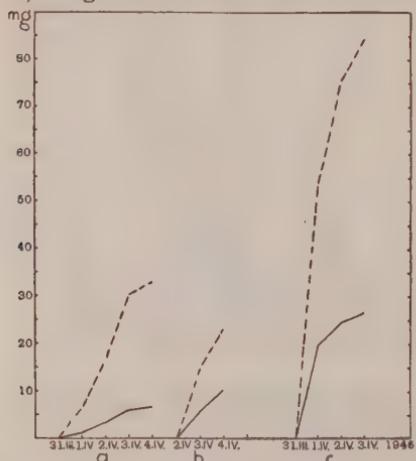


Fig. 25. Quantities of nectar produced during the lifetime of a single flower of: a and b — Shamouti orange, c — Bergamot orange; legend as in Fig. 23. Data from Mikveh Israel.

In Navel orange (Fig. 24b) maximum and minimum secretions are as above. A single flower of this plant secretes 13 mg. dry weight of nectar during the 3 days of its lifetime.

In Shamouti orange (Fig. 25a) maximum secretion occurred on the third and the minimum on the fourth and fifth (last) day of the flower's lifetime. The dry weight of the total nectar secreted by a flower was 6.5 mg. (N.B. We have observed much higher secretions in flowers of the Shamouti orange, but the data are not included here, as total secretion during the lifetime of these flowers was not measured.) The data in graph 25b are worthy of note. They are based on examinations during the first two days of the lifetimes of flowers which remained fresh thereafter, and they demonstrate a volume of secretion greater than in Fig. 25a (10.5 mg. in two days, with the greater secretion recorded on the first day).

Bergamot orange (Fig. 25c). A flower lives for three days. The dry weight of the nectar secreted during its lifetime is 26.75 mg. Maxima and minima are found on the first and last day respectively.

*Poncirus trifoliata*. A flower lives for five days and nectar production is scanty, being confined to the first two days alone.

VANSELL and WATKINS (1942) found that orange blossoms produce nectar before opening and for 48 hours following opening. According to my observations, nectar production continues for a more extended

period, 3 to 5 days in certain strains of orange, such as the Navel and the Shamouti strains.

(ix) NECTAR QUANTITY AND AGE OF INFLORESCENCE

Nectar quantities were measured for 11 days in two specimens of *Salvia leucantha* which had passed their flowering peak. Nectar produced by all of flowers which opened on a given day (2 to 5) was measured daily and averaged. Fig. 26a and b demonstrate that nectar production per flower decreases with the age of the inflorescence. PERCIVAL (1946) recorded similar results on *Rubus fruticosus*.

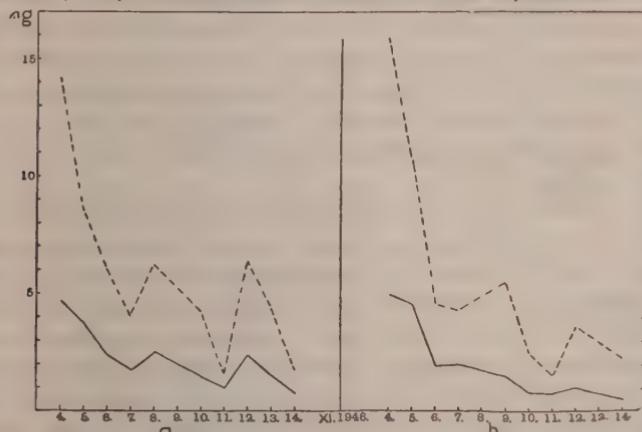


Fig. 26. Quantity of nectar secretion as related to the age of the inflorescence of *Salvia leucantha*; legend as in Fig. 23.

(x) NECTAR PRODUCTION IN MALE AND FEMALE FLOWERS

A male flower of *Musa paradisiaca* L. var. *sapientum* Kuntze was found to produce 422.7 mg. of fresh nectar daily, with a dry weight of 119 mg., whereas a female flower secreted 102 mg. of fresh nectar daily, with a dry weight of 26 mg. Thus, the male flower produced approximately 4.5 times as much nectar as the female. The nectary of the female flower occupies a limited space in the upper part of the ovary, whereas in the male flower it fills almost the entire rudimentary ovary. In *Cucurbitaceae*, on the other hand, the female flower is the chief producer of nectar as seen from Table 3.

TABLE 3

Name of plant	Fresh nectar in mg. male	Fresh nectar in mg. female	Dry nectar in mg. male	Dry nectar in mg. female
<i>Cucumis sativus</i>	2	4.5	0.5	1.5
<i>Cucurbita Pepo</i>	54.5	142.5	15.0	40.25
<i>Cucurbita maxima</i>	60.5	342.0	9.75	54.0

Apparently the tissue of the nectary is the determining factor in nectar secretion in the *Cucurbitaceae*, since the volume of this tissue in the female flower exceeds that in the male flower.

(xi) NECTAR PRODUCTION IN DETACHED FLOWERS AND IN FLOWERS ON DETACHED BRANCHES

BONNIER (1879) stated that root pressure and the capillary force of the water ducts accelerate secretion but are not essential to it. Many investigators have employed detached branches or flowers in studying the effect of external factors on nectar production.

In *Tecomaria capensis* no nectar was observed in detached flowers even when kept in a humid atmosphere, nor was any appreciable quantity of nectar secreted by flowers on detached branches kept in water. Thus *Tecomaria capensis* produces no nectar in the absence of root pressure; other plants may perhaps behave differently in this respect.

(xii) INJURY TO FLOWERS OR NECTARY AND NECTAR PRODUCTION

The results of our experiments with *Tecomaria capensis* are presented in Figs. 27 and 28. Flowers with removed corollas continued to secrete nectar though at a considerably reduced rate compared with controls. In addition, the nectar was extremely concentrated due to their complete exposure to evaporation. A normal, uninjured flower produced an average of 23.25 mg. of fresh nectar with a dry weight of 6.25 mg., whereas a flower with its corolla removed produced 3.25 mg. of fresh nectar with a dry weight of 3 mg.

Fig. 27. The effect of external injury to the flower and the nectary on nectar production in *Tecomaria capensis*; a: entire flower, b: flower with removed corolla, c: flower with nectary pierced with a pin; the black bars represent the dry weight, the white bars the water content of the nectar. Data from Jerusalem, Mount Scopus, 5.11.46.

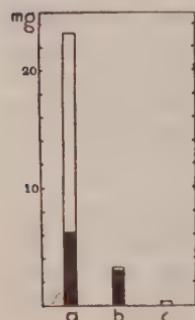
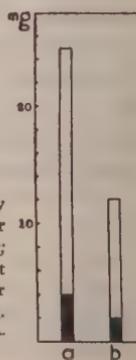


Fig. 28. The effect of external injury to the flower and the nectary on nectar production in *Tecomaria capensis*; flower and nectary covered with test tubes; a: entire flower; b: flower with removed corolla; legend as in Fig. 27. Data from Jerusalem, Mount Scopus, 6.11.46.



When corollas had been removed and the flowers covered not with the usual screen, but with test tubes, nectar secreted by the injured flowers was less concentrated than in the preceding experiment. Normal flowers produced an average of 25 mg. of fresh nectar with a dry weight of 4 mg.; while flowers without corollas secreted 12 mg. of fresh nectar with a dry weight of 2 mg. Thus nectar concentration was about equal in both cases, demonstrating that with the removal of the corolla nectar secretion decreases, while its original concentration remains constant. The concentrations varied in the preceding experiment due to an additional factor, exposure to evaporation.

#### SUMMARY

- (1) A new method for the quantitative measurement of nectar secretion has been devised.
- (2) 66 plants were investigated for their daily secretion of nectar which varies from 0.13 mg. fresh nectar with 0.10 mg. dry weight to 267.75 mg. fresh nectar with 74.37 mg. dry weight.
- (3) The quantity of nectar secreted is conditioned, among others, by the volume of the nectariferous tissue.
- (4) The concentration of dry matter in the nectar was examined — it varies from 14%—87%.
- (5) The proportion between the reducing and non-reducing sugars in the nectar varies from plant to plant. Some plants secrete reducing sugar only, some the non-reducing variety and others both kinds, in different proportions, which in some families are more or less constant.
- (6) No connection could be established between the quantity and concentration of the secreted nectar on one hand and the systematical position of the plant in question on the other.
- (7) Nectar secretion is influenced by air humidity, especially in exposed nectaries.
- (8) Higher temperature generally promotes nectar secretion.
- (9) Soil humidity, too, promotes nectar secretion. Its influence, however, is exerted not immediately after irrigation but one or two days later.
- (10) In most of the plants investigated for the daily rhythm of secretion the maximal secretion was found in the fore or afternoon, whereas in *Capparis sicula* the maximal secretion occurred at night.
- (11) Quantities of nectar secreted by single flowers on each day of their lifetime were measured. In most cases the highest secretion was found on the first day after the opening of the flower and the lowest on the last day of their life.

(12) The rate of secretion of the flower decreases with the age of the inflorescence.

(13) There are considerable differences in the rate of secretion between male and female flowers of the same species.

(14) Nectar secretion in *Tecomaria capensis* seems to be conditioned by root pressure, whereas in other plants local pressure in the tissues surrounding the nectary suffices.

(15) In *Tecomaria capensis* nectar secretion can be stopped almost entirely by injuring the nectary.

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# SNAPDRAGON RUST (*PUCCINIA ANTIRRHINI* DIET. ET HOLWAY) IN PALESTINE<sup>1</sup>

By I. WAHL

(With 5 figures in the text)

Snapdragon rust was first found in Palestine in 1936 (Rayss, 1937). Since then this rust has caused serious damage to cultivated *Antirrhinum majus* in this country. *Antirrhinum siculum* Ucr., growing wild in Palestine, has not been found affected by this disease.

## DESCRIPTION

The uredosori are yellowish-brown and found chiefly on the lower leaf surface, sometimes in concentric arrangement. The teliosori are dark-brown to black and occur later in the season, mostly on the stems or branches of the host. The uredospores are borne on long pedicels; their size was found to range from 16,5 to 21,5  $\mu$  on the leaf, from 18,5 to 33  $\mu$  on the stalk. The size of teliospores on leaf is 30,2 — 59,8  $\mu$  (average 42,2  $\mu$ ) and on the stalk 32,5 — 71,3  $\mu$  (average 50,34  $\mu$ ). Our data concerning teliospores are in agreement with those given by DIETEL (c.f. FAHRENDORFF, 1935). The teliospores are sometimes intermixed with amphispores. Basidiospores have been obtained by germinating teliospores in the laboratory but have not been observed in nature.

(a) *Seasonal development in Palestine.* Snapdragon rust makes its first appearance towards the end of August or early in September. In winter the uredospores spread from plant to plant, transmitting the disease. About the middle of March teliospores appear, but if the plants are deprived of their water supply entirely or partly, they can be made to appear as early as in February. The spread and development of the disease is halted in summer.

(b) *Germination and heat-resistance of uredospores.* Study of the influence of temperature on the germination of uredospores gave the following results: Minimum germination temperature of uredospores 1°C; optimum range for germination = 7—13°C; maximum germination temperature = 30°C. According to DORAN (1919) the optimum temperature is 10°C, according to ARONESCU-SAVULESCU (1939) 7—18°C. The percentage of germinating uredospores is unaffected by the presence or absence of light. The growth of germination tubes is especially rapid during the first hours of germination. In summer the germination capacity of the uredospores is greatly reduced.

Upon exposure to a temperature of 45°C for 5-6 hours, the germination ability of uredospores remains unchanged. After six hours at 60°C, however, the spores lose that capacity.

<sup>1</sup> This investigation was carried out in 1940.

(c) *Germination of teliospores.* DORAN (c.f. PELTIER, 1919) and ARONESCU-SAVULESCU (1939) made teliospore germination experiments without success. HOCKEY (1920-21) obtained germination in isolated cases. He concluded that germination depends on conditions prevailing at the time of spore-formation. We have attempted to germinate teliospores from plants affected during the previous year every month at 8°C, 14°C, 20°C, 25°C, 30°C. Germination was observed in February and March only. In February the following results were obtained: 8°C — 2%; 14°C — 5,5%; 20°C — 7%; 25°C — 8%; 30°C — 1%. In March we succeeded in obtaining basidiospores 46 hours after the beginning of germination. In April no germination could be observed. The application of hetero-auxin in various concentrations ( $10^{-3}$  —  $10^{-6}$ ), pre-cooling and storage with a view to further ripening, were of no avail.

#### TRANSMISSION OF THE DISEASE, INFECTION AND INCUBATION

The use of slides suspended in air has shown that uredospores are disseminated by wind. The disease was less evident on plants in places protected from wind. By the method described by ARONESCU (1934) it has been ascertained that the germination tube of the uredospore penetrates into the leaf through the stomata. Penetration occurs as early as 12 hours after the beginning of germination and the first haustoria appear 4-5 hours later. During penetration the tube thickens, forming appresoria. Incubation lasts 15 days. The end of incubation is marked by the appearance of chlorotic discolorations on which uredosori can be distinguished after a short time.

#### PHYSIOLOGICAL CHANGES IN SNAPDRAGON CAUSED BY RUST

Using the test for starch described by SCHNEIDER and ZIMMERMANN (1922), clearing of leaf tissue with alcoholic solution of chloral-hydrat and treatment with J+JK, disturbances in storage of starch in the affected leaves could be shown. Chlorotic spots as well as the green areas bordering on them contained no starch. RAWLINS (1933) obtained similar results in the case of *Puccinia Malvacearum* and concluded that the fungus hydrolyzes starch. The same conclusion may be drawn in our case.

Measurements by the Hartmann and Braun torsion-balance have revealed that transpiration is higher in affected than in healthy leaves. While a normal leaf loses 5,11% of its water content in five minutes, a diseased leaf loses 9,24%.

#### CYTIOLOGICAL INVESTIGATION OF FUNGUS AND HOST

The method used is described by EFTIMIU (1927), SINGALOVSKY (1937) and SCHNEIDER-ZIMMERMANN (1922).

*Vacuoles and plasma in the uredospore germination-tubes.* Neutral red was employed in concentrations of  $10^{-3}$  and  $10^{-4}$ , the latter being more suitable. In its early stages there is one vacuole only. Later the vacuole breaks up into several parts, which become localised in the distal end of the tube, the proximal end remaining empty (Fig. 1). Staining with Sudan III<sup>+</sup>methylene blue, revealed that plasma had accumulated at the tip and around the tube walls and fats concentrated in the vacuole area.

*Plasma of the hyphae.* Fixated in Regaud with postfixation in potassium bichromate and stained in erythrosin, the plasma was seen to concentrate in the haustoria at the tips of hyphae, especially in those which have penetrated the host. The pedicels of uredospores and teliospores appeared deeply stained.

*Nuclei in cells of fungus.* After fixation in Bouin and staining in Heidenhain iron hematoxylin, every mycelium cell showed two small nuclei close to each other in the direction of the long or the short axis of the cell (Fig. 2). In the uredospores both nuclei are near the tip. In the teliospores we have observed four nuclei prior to the formation of the transverse septa; just after its formation the two nuclei of the upper cell fused first. After the fusion of the two nuclei of the lower cell (Fig. 3) each cell was seen uninucleate.

*Nucleus and plastids of the host.* Fixation method used was as with hyphae. The fungus is particularly virulent to the host nucleus. The hyphae penetrate in the direction of the nucleus and encircle it. The nucleus then swells and subsequently disintegrates entirely (Fig. 4).

After fixation in Regaud and staining in J<sup>+</sup>JK the chloroplastids were seen to be affected by the fungus and finally destroyed (Fig. 5). These changes underly the appearance of chlorotic areas.

*Influence of various fungicides on uredospore germination.* Experiments with copper sulphate have shown that uredospore-germination is inhibited in concentrations as low as 1:10.000. Bordeaux Mixture is distinctly less effective, because some uredospores remain capable of germination even in 1% solution. Other fungicides such as sulphuric acid and phenol are less effective than copper sulphate. The minimum concentration for germination inhibition in each of these fungicides is 1:1000. In lower concentrations phenol solutions may even stimulate germination.

*Influence of KCl on the resistance of snapdragon towards *Puccinia Antirrhini*.* Nutrient solution prepared according to GASSNER and HASSEBRAUK (1931) contained:  $\text{NH}_4\text{NO}_3$  — 0.2 gr.,  $\text{Ca}_3(\text{PO}_4)_2$  — 0.2 gr.,  $\text{MgSO}_4$  — 0.25 gr.,  $\text{KCl}$  — 0.58 gr.,  $\text{NaCl}$  — traces,  $\text{FeCl}_3$  — traces,

$\text{H}_2\text{O}$  — 1000 cc. Experiments conducted in laboratory pots have proved that KCl nutrition increases the resistance of snapdragon to rust. This is particularly evident when the KCl concentration is increased three or five times. Further additions of KCl concentration (x 8) reduce its immunity as compared to x 3 and x 5.

The author is grateful to Dr. T. RAYSS for her help and valuable suggestions throughout the course of this investigation.

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#### EXPLANATION OF FIGURES

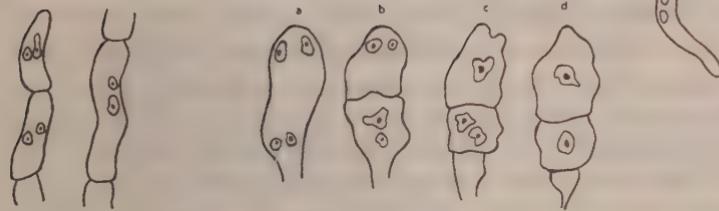
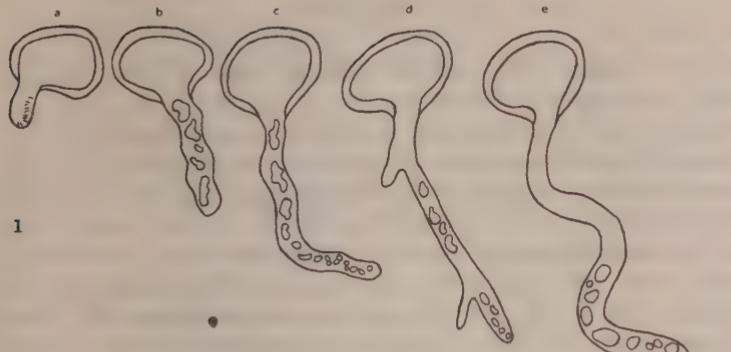
Fig. 1. Changes of the vacuolar system in the uredospore-germination tube. — The vacuole of a very young germination-tube breaks into smaller drops which finally accumulate in the distal part of the tube.

Fig. 2. Arrangement of the nuclei in hyphal cells (along their long or short axis).

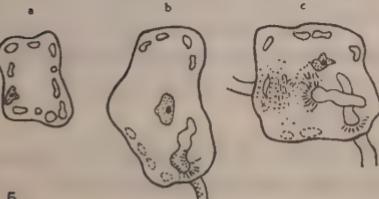
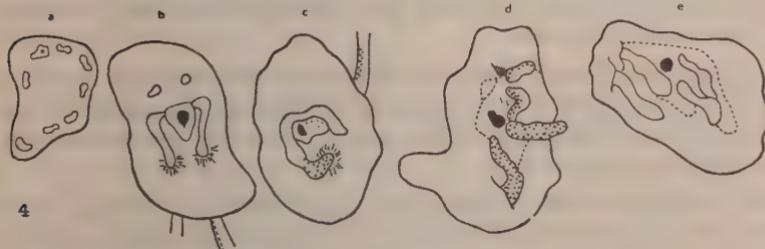
Fig. 3. Nuclei of teliospore before and after fusion (explanation in the text).

Fig. 4. Disintegration of the host-cell nucleus affected by fungus: a — normal cell with nucleus and plastids; b-c — encircled nucleus swells; d-e — final stages, nucleus completely dissolved.

Fig. 5. Disintegration of chloroplastids in affected host cell: a — cell with normal chloroplastids; b-c — some of the plastids ill-defined and dissolved.



3



## LEAF SPOT DISEASES OF *IRIS* IN PALESTINE

By T. KUSHNIR<sup>1</sup>

Many *Iris* species grow wild in Palestine, some of them endemic. During the course of study on the ecology, distribution, taxonomy and cytology of the Palestinian Irises the author became interested in two diseases of common occurrence in nature or in cultivation: *Septoria* leaf-spot, caused by *Septoria Iridis* C. Massalongo, and *Heterosporium* leaf-spot, caused by *Heterosporium gracile* Sacc. *Septoria* causes small round or elongated spots, pale grey with a brownish border; its numerous pycnidia occur under the cuticle and are 112—175 $\mu$  in diameter; the pycnospores are 15—35 x 3—5 $\mu$  and are mostly uniseptate. The *Heterosporium* forms pale elliptic spots drying up afterwards with a brown edge. The conidiophores are up to 70 x 10 $\mu$  and bear olive-green 2—3 septate prickly conidia; 40—63 x 15—21 $\mu$ .

Some of our observations on diseased *Iris* plants are recorded here.

*I. Lorteti* Barb. The plants collected near Ayeleth-Hashahar in 1944 were planted in Kefar Yeheskiel where they flowered in 1945 and then were transplanted to the Hebrew University Botanical Garden in Jerusalem. Late in December 1945 and early January 1946 both the *Septoria* and the *Heterosporium* disease appeared on a few leaves. The following species were growing in the same flower-bed close to these plants: *I. Haynei* var. *pallida* and *I. nazarena*. The two former were strongly infected with *Septoria*, the latter was slightly infected both with *Septoria* and *Heterosporium*.

*I. nazarena* (Foster) Dinsm. Collected in Ghiv'at-Hamoreh in 1943 and 1944 and planted in the Botanical Garden. At the end of December 1946 small numbers of *Heterosporium* spots and very few *Septoria* lesions were observed.

*I. atropurpurea* Bak. Collected near Even-Yehuda in 1944 and 1945 and planted in the Botanical Garden, this species first showed symptoms of *Septoria* leaf-spot late in January 1946. The neighbouring plants were *I. nazarena* slightly infected both with *Septoria* and *Heterosporium*. During the winter of 1946 the author visited the natural habitat of *I. atropurpurea* near Kefar Neter and found the plants there also suffering rather severely from *Septoria*. *I. atropurpurea* has not been found with an *Heterosporium* infection.

*I. Haynei* Bak. In the winter of 1945 plants of this species growing in the Botanical Garden were severely infected with *Septoria*. Accord-

<sup>1</sup> Posthumous.

ing to RAYSS (1943) the same species was found diseased in the garden of Ain-Harod, while other species in the same garden remained free of the fungus. In nature also, on Mount Gilboa, *I. Haynei* suffered from *Septoria* leaf-spot. We did not find any plant attacked by *Heterosporium*.

*I. Haynei* Bak. var. *pallida* Kushnir, var. *nova*<sup>1</sup> was collected on Mt. Gilboa in 1942 and planted in the Botanical Garden in Jerusalem. This variety suffered very severely from *Septoria* leaf-spot in 1945. During the winter of 1946 the disease abated somewhat, but remained more severe than on other species. *Heterosporium* was not found.

*I. Pseudo-Lorteti* Kushnir, sp. *nova*<sup>1</sup>. Collected on Mt. Gilboa in 1944, flowered in Jerusalem in 1945. This species remains almost completely free from infection with *Septoria*, while others in the same flower-bed (*I. Haynei* and *I. Haynei* var. *pallida* were severely diseased. Very little *Septoria* appeared on this species during the winter of 1946. It is not attacked at all by *Heterosporium*.

*I. loessicola* Kushnir, sp. *nova*<sup>1</sup>. In its natural habitat — the loess fields around Tel-Arad — some plants were infected by *Septoria*. However, the diseased plants constituted no more than 1-2% of the population and their symptoms were slight, showing lesions only around the margins of the leaves.

These observations suggested that different species have different degrees of resistance or immunity against *Septoria* and *Heterosporium* leaf-spot. To test this we carried out infection experiments on 10 different species of *Iris*.

The inoculations were made with blocks of agar containing hyphae and reproduction organs from pure cultures of *Septoria Iridis* and *Heterosporium gracile*, both originally isolated from infected *Iris* leaves. These blocks were put on detached leaves which were kept with their base immersed in water, under bell-jars in the laboratory. Uninoculated leaves of the same species served as controls and were kept under identical conditions. The inoculations were carried out on April 4, 1946. The results were recorded on April 11th in the case of *Septoria*, and on April 14th in the case of *Heterosporium*. They are summarised in the following table (Table I).

<sup>1</sup> Not yet been published.

TABLE 1.

Species of <i>Iris</i>	<i>Septoria</i> inoculations (results recorded after 7 days).	<i>Heterosporium</i> inoculations (results recorded after 10 days).
I. Section <i>Oncocyclus</i> (Siem.) Bak.		
1. <i>I. Lorteti</i> Bak.	Severely infected in one case; in another slight symptoms only, not at the point of inoculation.	Successfully infected. Large typical lesions. Abundant conidia on both sides of the leaf.
2. <i>I. nazarena</i> (Foster) Dinsm.	Doubtful.	All inoculations successful. Large lesions with very large numbers of conidia.
3. <i>I. atropurpurea</i> Bak.	One lesion, not at the point of inoculation.	Weakly infected; conidia present.
4. <i>I. Haynei</i> Bak.	Severely infected.	About half of the inoculations successful; small typical lesions. A few conidia on one spot.
5. <i>I. pseudo-Lorteti</i> Kushnir	Slight infection.	A small number of inoculations successful. Spots small, atypical (no central dark area). Very few conidiophores, no mature conidia.
6. <i>I. hauranensis</i> Dinsm.	Slightly attacked?	No infection.
7. <i>I. Helenae</i> Bak.	Doubtful.	Infected, conidia present.
8. <i>I. nigricans</i> Dinsm.	Not at all infected.	Very slight infection, conidia present.
II. Section <i>Pogoniris</i> Bak.		
9. <i>I. mesopotamica</i> Dykes (= <i>I. germanica</i> L., p.p.)	No infection.	No infection.
10. <i>I. albicans</i> Lange (= <i>I. florentina</i> L. var. <i>alba</i> Lange)	No infection.	No infection.
	Controls: all free from disease, except <i>I. pseudo-Lorteti</i> and <i>I. nazarena</i> .	Controls: all free from disease.

## SUMMARY AND RESULTS

*Iris Lorteti* is susceptible to the two diseases but is only slightly infected in nature.

*I. nazarena* is fairly resistant to *Septoria* but is strongly infected by *Heterosporium*, especially in infection experiments.

*I. atropurpurea* in nature suffers rather severely from *Septoria* but not from *Heterosporium*. The inoculations proved that it can be weakly infected with *Heterosporium* too.

*I. Haynei* suffers greatly from *Septoria* leaf-spot in nature and in cultivation and was also strongly attacked in our experiments. *Heterosporium* was not found in nature and produced by inoculation small typical spots. *I. Haynei* var. *pallida*, however, is still more susceptible to *Septoria*; in fact, of all the species studied it is the most susceptible. Infected plants are stunted and flower poorly. This variety also suffers most from aphids.

*I. pseudo-Lorteti* is attacked only slightly by *Septoria*, even if in close proximity with strongly infected *I. Haynei* and *I. Haynei* var. *pallida*. *I. pseudo-Lorteti* also showed a high degree of resistance to artificial inoculation, both of *Septoria* and *Heterosporium*.

It should be noted that the new species, *I. pseudo-Lorteti*, and the new variety, *I. Haynei* var. *pallida* were collected only once on Mt. Gilboa, the natural habitat of *I. Haynei*, and each of them represents a clon.

The two species of the section *Pogoniris* did not prove susceptible to either *Septoria* or *Heterosporium* in our experiments. However, *I. mesopotamica* which is common in Moslem cemeteries has been found in Ain-Karem and other localities to be suffering from *Heterosporium* (SAVULESCU and RAYSS, 1935). It would be of interest to extend the inoculation-experiments with different strains of these fungi.

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# PLANTS NEW FOR THE FLORA OF IRAQ

BY M. ZOHARY

Recently R. A. BLAKELOCK published in the *Kew Bulletin* (1948, No. 3 and 1949, No. 1) a systematic list of plants of Iraq from the collection of the Rustam Herbarium made by E. R. GUEST. This list includes, among others, dicotylous plants of the Rustam Herbarium Iraq duplicates of which are found in the Kew Herbarium.

As this list does not comprise by far all the species hitherto collected in Iraq I found it necessary to compile an additional list of species not mentioned by the above author and as yet not recorded for Iraq. The present list comprises vascular plants collected in spring and autumn of 1933 by A. EIG and the author and also some species kindly presented to us by E. R. GUEST. The collections are located in the Herbarium of the Hebrew University, Jerusalem, and are fully labelled. For certain reasons, however, it has not been possible to bring here details of the locality and habitat.<sup>1</sup>

## POLYPODIACEAE

*Ceterach officinarum* Lam. et DC. — R.<sup>2</sup>  
*Cheilanthes Szovitsii* F. et M. — Su, A.  
*Phyllitis Scolopendrium* (L.) Newm. — Su.

## SALVINIACEAE

*Marsilia aegyptiaca* Willd. — LM.

## PINACEAE

*Pinus Brutia* Ten. — A.

## POTAMOGETONACEAE

*Potamogeton fluitans* Roth. — Su.

*Potamogeton crispus* L. — LM.

*Potamogeton pusillus* L. — Su.

*Zannichellia palustris* L. — Su.

*Ruppia maritima* L. — LM.

*Alisma lanceolatum* Witker — LM.

## GRAMINEAE

*Digitaria sanguinalis* (L.) Scop. — Su.

*Setaria glauca* (L.) Beauv. — R.

*Setaria viridis* (L.) Beauv. — R.

*Erianthus Hostii* Griseb. — A.

*Andropogon ischaemum* L. — R.

*Phalaris brachystachys* Lk. — D.

*Phalaris nodosa* L. — A.

*Rhizocoephalus orientalis* Boiss. — Je.

*Phleum tenue* Schrad. — A, Su.

*Alopecurus anthoxanthoides* Boiss. — Su.

*Alopecurus arundinaceus* Poir. — A, Su.

*Oryzopsis miliacea* Asch. et Schw. — D.

*Oryzopsis holciformis* (M.B.) Hack. — Su.

*Gastridium lendigerum* (L.) Gaud. — A.

*Trisetum Cayanillesii* Trin. — A.

*Avena pilosa* M.B. — Si.

*Avena clauda* Dur. — Si, A, E, Ki, D.

*Arrhenatherum palaestinum* Boiss. — Ki.

*Echinaria capitata* (L.) Desf. — Si, A, Su, Ki, D.

*Eragrostis minor* Host. — Su.

*Melica inaequiglumis* Boiss. — R.

<sup>1</sup> The collections of Iraquian plants in the Herbarium of the Hebrew University, comprising over a thousand of species, were identified during the years 1942-1944 by the author. As a result of this work a paper was prepared at the request of the Iraq Ministry of Agriculture containing a more or less complete catalogue of the Iraq Flora and its phytogeographical analysis. It was submitted to the above Ministry for publication and the final proofs of this paper were read in 1947, but, apparently, it has not been published till now. The following list has been extracted from the above mentioned catalogue.

<sup>2</sup> The abbreviations used are as follows:

A = Amadia, mountainous area in N.  
Iraq

D = Dohuk district, hills

E = Erbil area

Je = Jezireh

LM = Alluvial plain of Southern Iraq

Ki = Kirkuk area

R = Ravanduz area

SD = Southern part of the Syrian Desert

Si = Jebel Sindjar

Su = Sulaimani area

WD = Western part of the Syrian Desert.

*Vulpia ciliata* (Pers.) Link. — Ki, D, Je.  
*Vulpia Myuros* (L.) Gmel. — LM, D, Je.  
*Vulpia hirtiglumis* Boiss. et Hausskn. — Su.

*Bromus tectorum* L. — Si, A, R, Su, Ki, LM, D.

*Bromus scoparius* L. — Ki, LM, D, WD.

*Bromus alopecurus* Poir. — A.

*Brachypodium sylvaticum* (Huds.) Roem. et Schult. — Su.

*Agropyrum panormitanum* Parl. — A, R, Su.

*Agropyrum Aucheri* Boiss. — R, Su.

*Heteranthelium piliferum* Hochst. — Si, Su, Ki, D, Je.

*Triticum Thaoudar* Reut. — A.

*Aegilops speltoides* Tausch. — A, R.

*Aegilops crassa* Boiss. — Si, Ki, LM, Je.

*Aegilops variabilis* Eig — LM.

*Aegilops columnaris* Zhuk. — Si.

*Aegilops triariata* Willd. — A.

*Aegilops umbellulata* Zhuk. — A, Si, R.

*Lepturus incurvatus* (L.) Trin. — LM, Je.

#### CYPERACEAE

*Cyperus fuscus* L. — R.

*Cyperus glaber* L. — Su.

*Heleocharis uniglumis* Link. — Ki.

*Cladium Mariscus* (L.) R. Br. — A.

*Carex pachystylis* Gay. — E, Ki, LM, SD, WD.

#### ARACEAE

*Biarum angustatum* (Hook. f.) N. E.

Brown — R, Su, A, D.

#### LILIACEAE

*Tulipa Stapfii* Turill — R.

*Gagea dubia* Terrac. — A.

*Gagea ambiopetala* Boiss. et Heldr. — A.

*Gagea reticulata* Pall. — Ki.

*Gagea tenuifolia* (Boiss.) Fomin — Ki, D, SD, WD, Je.

*Scilla autumnalis* L. — A, R.

*Scilla persica* Hausskn. — A.

*Allium Ampeloprasum* L. — S.

*Allium sphaerocephalum* L. — Ki.

*Allium Akaka* Gmel. — E, Ki, D.

*Allium Schuberti* Zucc. — Je.

*Muscaria comosum* Mill. — D.

*Asphodelus microcarpus* Viv. — A, E, D.

*Sternbergia Fischeriana* Herb. — A.

#### DIOSCORACEAE

*Tamus communis* L. — A.

#### IRIDACEAE

*Iris Sisyrinchium* L. — Ki, LM, D, SD, WD, Je.

*Gladiolus segetum* Gawl. — Ki.

*Gladiolus atrovioletaceus* Boiss. — A, E, Ki, D.

#### ORCHIDACEAE

*Orchis saccata* Ten. — D.

#### LORANTHACEAE

*Arceuthobium Oxycedri* (DC.) M.B. — A.

#### POLYGONACEAE

*Rumex scutatus* L. — Su.

*Polygonum nodosum* Pers. — Si, R.

*Polygonum Bellardi* All.

#### CARYOPHYLLACEAE

*Dianthus anatolicus* Boiss. — A, R, Su.

*Dianthus pendulus* Boiss. — Su.

*Silene affinis* Boiss. — Ki.

*Silene stentoria* Fenzl. — R.

#### BERBERIDACEAE

*Leontice minor* Boiss. — WD.

#### CRUCIFERAE

*Arabis auriculata* Lam. — Je.

*Arabis Aucheri* Boiss. — Su.

*Erysimum tenuissimum* J. Gay. — A, Su.

*Conringia persica* Boiss. — Su.

*Alliaria officinalis* DC. — Si, R.

*Alyssum strigosum* Banks et Sol. — Si, R, Ki, Su, D.

*Alyssum meniocoides* Boiss. — Si, A, E, Ki, Su, D.

*Erophila praecox* (Stev.) DC. — Ki, Su, D.

*Erophila setulosa* Boiss. et Bal. — A, R.

*Notoceras bicornis* (Ait.) Caruel — D.

*Sameraria armena* (L.) Boiss. — WD.

*Bunias orientalis* L. — D.

#### ROSACEAE

*Sorbus Aria* Crantz — A.

*Poterium villosum* S. et S.

#### LEGUMINOSAE

*Trigonella astroites* Fisch. et Mey. — Ki, D, Je.

*Trigonella Fischeriana* Ser. — Si.

*Trigonella hamosa* L. — LM.

*Trigonella anguina* Forsk. — SD.

*Medicago lupulina* L. — Su.

*Medicago tuberculata* Willd. — Su.

*Medicago coronata* Lam. — Si.

*Trifolium Cherleri* L. — Ki, Su.

*Trifolium formosum* Urv. — Si, Su, D.

*Scorpiurus subvilloso* L. — Ki, Su, LM, D.

*Hippocrepis unisiliquosa* L. — Si, E, Ki, Su, D, Je.

*Vicia varia* Host. — LM.

#### THYMELAEACEAE

*Stellera Lessertii* (Wikstr.) C.A.M. — Je.

*Lygia Paserina* (L.) Fas. — A, R, D.

#### ONAGRACEAE

*Epilobium montanum* L. — R, Su.

*Epilobium roseum* Schreb. — Su.

#### ARALIACEAE

*Hedera Helix* L. — A.

#### UMBELLIFERAE

*Bifora testiculata* Roth — Si.

*Smyrnium cordifolium* Boiss. — Su.

*Prangos pabularia* Lindl. — A.  
*Ferula Blanchetii* Boiss. — WD.  
**PRIMULACEAE**  
*Asterolinum Linum-stellatum* (L.) Duby — Ki, D, Je.  
**PLUMBAGINACEAE**  
*Plumbago europaea* L.  
**OLEACEAE**  
*Fraxinus oxyphylla* M.B. — A, R, Su.  
**GENTIANACEAE**  
*Gentiana verna* L. — R.  
**APOCYNACEAE**  
*Vinca libanotica* Zucc. — Si, R, Ki, Su, D.  
*Apocynum Venetum* L. — Su.  
**ASCLEPIADACEAE**  
*Cynanchum Tmoleum* (Boiss.) Schum. — R.  
**CONVOLVULACEAE**  
*Cuscuta arabica* Fres. — SD.  
**BORAGINACEAE**  
*Heliotropium myosotoides* Banks et Sol. — A.  
*Heliotropium Borei* Boiss. — A.  
*Anchusa orientalis* (L.) Rchb. — R.  
*Nonnea ventricosa* (S. et S.) Griseb. — Je.  
*Lithospermum incrassatum* Guss. — Si.  
*Lithospermum tenuiflorum* L. (fil.) — Si, Ki, D, Je.  
*Alkanna Kotschyana* DC. — A.  
*Myosotis alpestris* Schm. — R.  
*Myosotis silvatica* (Ehr.) Hoffm. — R.  
*Myosotis collina* Hoffm. — D.  
*Rochelia disperma* (L.) Wett. — Si.  
*Lappula Szowitsiana* (F. et M.) Hand.-Mzt. — S, Ki, D, Je.  
*Lappula sessiliflora* (Boiss.) — Je.  
*Cynoglossum creticum* Mill. — LM.  
*Mattia lanata* (Lam.) Schult. — Si.  
*Trichodesma incanum* Beg. — Su.  
**VERBENACEAE**  
*Verbena officinalis* L. — A.  
**LABIATAE**  
*Teucrium multicaule* Montb. et Auch. — D.  
*Teucrium Tailori* Boiss. — Si, Je.  
*Brunella vulgaris* L. — R.  
*Marrubium astrachanicum* Jacq. — R.  
*Sideritis montana* L. — R.  
*Nepeta teucriifolia* Willd. — Su.  
*Nepeta Trautvetteri* Boiss. et Buhse — R.  
*Stachys longespicata* Boiss. et Ky. — D.  
*Salvia ceratophylla* L. — Ki, D.  
*Salvia Russelii* Bth. — D.  
*Zizyphora Abd-el-Azizii* Hand.-Mzt. — WD.  
*Calamintha graveolens* M.B. — Si.  
*Satureja intermedia* C.A.M. — R.  
*Satureja macrantha* C.A.M. — A.  
*Lycopus europaeus* L. — R.  
*Mentha silvestris* L. — A, R, Ki, Su.  
**SOLANACEAE**  
*Solanum Dulcamara* L. — Su.  
**SCROPHULARIACEAE**  
*Kickxia Sieberi* (Rchb.) Defl. — A, R, Ki, Su, LM.  
*Linaria arvensis* (L.) Desf. — R, Su, D.  
*Linaria genistifolia* (L.) Mill. — R.  
*Linaria chalepensis* (L.) Mill. — Ki, D.  
*Linaria ascalonica* Boiss. et Ky. — SD.  
*Linaria persica* Chav. — Ki, D.  
*Scrophularia macrophylla* Boiss. — Su.  
*Scrophularia pruinosa* Boiss. — Su.  
*Veronica agrestis* L. — R.  
*Euphrasia latifolia* (L.) Griseb. — Su, D.  
**PLANTAGINACEAE**  
*Plantago lanceolata* L. — A, Su.  
*Plantago Psyllium* L. — Ki, D, Je.  
**RUBIACEAE**  
*Asperula orientalis* Boiss. et Hoh. — D.  
*Vaillantia hispida* L. — D.  
**VALERIANACEAE**  
*Valerianella diodon* Boiss. — Je.  
**DIPSACEAE**  
*Dipsacus laciniatus* L. — R.  
**CAMPANULACEAE**  
*Campanula glomerata* L. — R.  
*Campanula stellaris* Boiss. — Su, Ki.  
*Campanula Erinus* L. — D.  
**COMPOSITAE**  
*Lachnophyllum Noëanum* Boiss. — Su.  
*Eyax contracta* Boiss. — Ki, D.  
*Aaronsohnia Faktorowskyi* Warb. et Eig. — SD.  
*Chamaemelum decipiens* F. et M. — Su.  
*Xeranthemum longepapposum* F. et M. — R.  
*Chardinia xeranthemoides* Desf. — Si, Ki, D, Je.  
*Carlina lanata* L. — D.  
*Atractylis flava* Desf. — SD.  
*Atractylis cancellata* L. — Ki.  
*Lappa major* Gaert. — R, Su.  
*Cirsium lanceolatum* (L.) — Su.  
*Centaurea Szowitsiana* Boiss. — R.  
*Lactuca aculeata* Boiss. et Ky. — A, Su.  
*Lactuca orientalis* Boiss. — Je.  
*Lagoseris sancta* (L.) Maly — D.  
*Lagoseris obovata* (Boiss. et Noë) Bornm. — Ki, D, Je.

## PLANTS NEW FOR PALESTINE III.

BY NAOMI FEINBRUN

*Viola ebracteolata* Fenzl. — Boiss. 1: 468.

Upper Galilee, between Safed and Biria (1949 *Ariva Kushnir*).

DINSMORE in POST-DINSMORE (1932) records two specimens of this species (under *V. modesta* Fenzl var. *parviflora* Fenzl) from two localities in Gilead (Suf and Ajlun) erroneously indicated as in the Lebanon. Ours is the first record from Cis-jordania. — This is an East-Mediterranean species.

*Trifolium glanduliferum* Boiss. var. *albiflorum* Feinbr. var. nov.

*Flores albi, cetera ut in typo.*

Jerusalem, grassy places near a Pine wood, together with the type and *Trifolium scutatum* (1949 Feinbrun).

*T. glanduliferum* is closely related to *T. nervulosum*, and differs from it morphologically only by the presence of stipitate glands at the ends of the teeth of leaflets and stipules. The two species, however, differ in their habitat and area of distribution. *T. glanduliferum* grows in the Batha on terra-rossa soil in the Judean Mountains, in Moab and Gilead, whereas *T. nervulosum* is confined to sandy habitats of the Coastal Plain of the country (Negev, Shefela, Sharon, Acre Plain, Upper Galilee).

*Lythrum thymifolia* L. — Boiss. 2:740.

Shefela, Wadi Rubin, depression between dunes, heavy soil inundated in winter (27.8.1944 *Halevi*).

New to the Flora of POST.

*Rochelia disperma* (L.) Wetst. — in Stapf (1885); Boiss. 4: 244 (sub *R. setulata* Rchb.).

Judean Desert, Hebron to Masada (8.4.1943 *Halevi*).

*Majorana syriaca* (L.) Feinbr. comb. nov.

This species is quoted under *Origanum Maru* L. by EIG (1932) for Palestine and by POST-DINSMORE (1933) for Palestine, Lebanon, Syria and Sinai. However, HOLMBOE (1914) pointed out that the Palestinian and Syrian plant is *O. syriacum* L., whereas *O. Maru* L. (= *O. microphyllum* Boiss.) occurs only on Crete.

I named our plant *Majorana syriaca* (L.) Feinbr. following the conception of *Origanum* s.l. by BRIQUET and others, and accepted *Amaracus*, *Origanum* s.s. and *Majorana* as distinct genera.

*Stachys aegyptiaca* Pers. — Post 2:381.

Southern Negev, Wadi Nafkh, near Abda, bed of wadi (1945 *D. Zohary*); bed of Wadi Khalassa, near Asluj (1949 *J. De Angeles*).

*Ballota Kaiseri* Taekh. — W. Taeckholm, Some new plants from Sinai and Egypt: 378.

Southern Negev: near Asluj (1944 Feinbrun); Qurnub to Naqb es-Safi (1948

*D. Zohary*; Abda, rocky bed of Wadi (1945 *D. Zohary*).

*Euphorbia nutans* Lam. — Hayek, Prodr. Fl. Balc. 1:138.

Jerusalem, Mt. Scopus, irrigated plots (1944 Feinbrun). Adventitious from America.

*Euphorbia prunifolia* (Jacq.) Muell. (= *E. geniculata* Ortega). Muschler, Man. Fl. of Egypt: 608.

Jericho, irrigated orchard (1944 *T. Kushnir*).

New to the Flora of POST. THELLUNG (1912) records it as adventitious from Tropical America.

*Ceratophyllum submersum* L. — Hegi 3:450.

Huleh, western shore of Lake, in water (1947 *Haran*).

The geographical area of this plant (cf. Flora of USSR) comprises Europe, W. Siberia, Caucasus, Middle Asia. In the Mediterranean region it is recorded as far East as the Balkans. It can thus be designated as an Eurosiberian-Boreoamerican-Mediterranean-Irano-Turanian species.

New for the region of BOISSIER'S Flora Orientalis.

*Allium rotundum* L. (Sect. *Porrum*) — Sp. pl. 423.

Upper Galilee, Ras el Ahmar, N. of Safed, fallow field on basalt soil (1949 *D. Zohary*).

New for the flora of Palestine. As stated elsewhere (FEINBRUN 1943) *A. cilicicum* Boiss. is included within *A. rotundum*. Comparison of living material from Europe with that from Asia Minor, Syria and Palestine would be worthwhile.

*Stipa Hohenackeriana* Trin. et Rupr. — Boiss. 5: 502; Fl. USSR 2: 92.

Southern Negev, Wadi Ruman (1946 *Halevi*).

Record new for Western Palestine.

*Eremopyrum orientale* (L.) J. et Sp. — Boiss. 5: 668; Jaub. et Sp. Ill. Pl. Orient. 4: 26.

Southern Negev, Wadi Ruman (1946 *Halevi*).

Record new for Western Palestine.

## CARPOBIOLOGICAL NOTES ON *ALYSSUM*

BY M. ZOHARY

The genus *Alyssum* comprises over one hundred species, perennials and annuals, the latter almost exclusively confined to arid regions. Although the silicle of *Alyssum* is uniform throughout the whole genus its dispersal biology appears rather complex. I have examined several annual species of the Near East countries and found the following dispersal types:

(1) *Anemochorous species*. The silicles retain their primary position on the floral axis (replum median, valves transversal): Soon after ripening (in spring) the valves detach from the replum by means of a separation tissue and the seeds are dispersed by wind. Most of the species of the genus come under this category.

(2) *Ombrochorous species*. The valves of the silicles are brought into the median position at an early stage. The separation tissue is less developed and the silicles do not open during the entire dry season. The lower valve is much more convex than the upper; only one seed is found in the upper cell, rarely none, while in the lower are generally two seeds. The fruiting pedicels are spreading and do not change their direction when moistened. *A. strigosum* Banks et Sol., *A. parviflorum* M.B. and other come under this category.

The above characteristics are in strict conformity with the mode of dispersal peculiar to these plants. Contrary to the anemochorous species the ombrochorous species keep their mature fruits closed during the summer. The broad valves brought into the median position enlarge considerably the surface exposed to the stormy winter rains. The mechanical effect of the rain on the valves results in the loosening of the valves from the replum and penetration of water into the cells. This is followed by a strong exudation of mucilage from the seed testas within the loculi and the swelling of the seeds to such an extent as to cause the opening of the valves and their final detachment from the replum. The lower valve, however, forced by two swelling seeds is the first to be removed. Further impact of rain drops causes the slimy seeds to leave the replum and to adhere to the ground where germination usually occurs shortly.

(3) *Ombrochorous — hygrochastic species*. A more elaborate dispersal apparatus is found in those species where ombrochory is coupled with hygrochastic movements of the pedicels, as found for *A. damascenum* Boiss. et Gaill., *A. marginatum* Steud., *A. pyramidatum* Bornm., *A. Szowitsianum* F. et M., etc. Here the fruiting pedicels turn upwards after ripening of the fruit and become pressed to the fruiting axis. Moistened by the first winter rains the pedicels spread horizontally. The

position of the valves, their inequality, the number of seeds and their way of dispersal are the same as in the last type.

The anatomical reasons for the hydrochastic movements of the pedicels have been described by ZOHARY and FAHN (1941). Hydrochasy in this as in several other cases may be regarded as an additional means of exposing the fruit to a maximum extent. By keeping the silicules appressed to the stem during the dry season, ombrochory is almost exclusive since in this position all other dispersal factors cannot act freely upon the fruit.

Ombrochory has been observed in several species (MUELLER 1935). It is very common in arid and semiarid regions. Here it is no doubt an antitelechorous phenomenon (ZOHARY 1937) in that seed dispersal is limited to the rainy season, most unfavourable for long distance transport of the seeds which readily germinate when reaching the moist soil.

Apart from ombrochory there is a series of other antitelechorous phenomena such as geocarpy, amphicarpy, heterocarpy, etc. very characteristic of arid regions. It seems that in these regions dispersal in loco has some advantages over long distance dispersal in offering to the next generation a habitat already "chosen and proved favourable" by the parent plant.

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## צמחים חדשים לפולורה של עירק

מאט. זהרִי

ברשימה שבעמ' 234 מובאים קרוב ל-200 מינים אשר טרם נמצאו בגבולותיה של עירק, החומר הוגדר ע"י המחבר מתן האספין שברשות המחלקה לבוטניקה. הוא נאשך בעיקר בשנת 1933 ע"י א. איג ו. מ. זהרִי ובחלוּקו גם ע"י ג. פינברון, מ. אבן-ארִי ואחרים.

## צמחים חדשים לארץ-ישראל III

מאט. ג. פינברון

נתנת חוספת שלישית של מיני צמחים חדשים לארץ-ישראל שנמצאו בה בשנים האחרונות. ברשימה מפורטים 11 צמחים חדשים לארץ כליה או לעבר הירדן המערבי. אחדים מהם אינם כוללים בפלורות של בואסיה או של פוטט. נתן תואר של זו חדש למדע וקומבינציה חדשה בכוּנוֹו של מין אחד.

## הערות ביולוגיות בתפוצת הזרעים של *Alyssum*

מאט. זהרִי

הסוג אליסון מונה כמאה מינים מהם מעוניינים באופן מיוחד החד-שנתיים בביולוגיות של התפוצות פירוחיהם. אפשר להלך לשולשת טפסות:  
 (א) אומברוכריים. קשותות הפרי נתקoot עם ההבשלה בклות מהרפלום וזרעים נמצאים בנקל על ידי הרוח (הרוב הגדול של המינים). אצל הללו נשמרת העמדת החזקיות של הפרי לגבי הציר (כלומר המהיצה עומדת במדיאנה הקשוחות בצדדים).  
 (ב) אומברוכוריים. קשותות הפרי אינן נתקoot מהרפלום עם ההבשלה והפרי נשאר סגור כל הקץ. הקשותות נמצאות במדיאנה. עם הרטב הפרי בימי הגשמי נפרדות הקשותות אך אינן נופלות מהפרי אלא לאחר שהמים אשר הרטבו אותו קלפת הזרע גרמו ליצירת כסות עבה של ריר על פניה. בכה תגדלת נפחם של הזרעים נתקoot הקשותות מהפרי והזרעים הנופלים מעל המהיצה מגיעים מוחה לביטות.

(ג) אומברוכוריים-היגרוכסטיים. עוקציו הפירות ההיגרוכסטיים עשויים כאן להתנווע עם חלופי הלחות. עם הבשלה הפרי, בראשית תקופת היובש, נצמדים עוקציו הפירות אל ציר התפרחת ונשארים במעטם זה כל הקץ. עם רדת הגשמי הראשוניים נרטבים העוקצים ונפשקים לצדדים וע"כ מופנים הפירות לעמדת אופקית ותגשים יכול להתקипם בנקל ולסייע להפצת זרעים כמופרש אצל האומברוכוריים.

## מחלת החלדוֹן Puccinia Antirrhini Diét. et Holway

### על לוע האРИה

מאת י. ואהֶל

מחלת החלדוֹן Puccinia Antirrhini Diét. et Holway על לוע האРИה שנתגלתה בארץ ישראל לראשונה בשנת 1936 על ידי ד"ר ט. ריסי התפשטה במהירות וגרמה לנזקים רציניים למד. בעבודה זו נתנות תוצאות של הסתכלויות וניסיונות בחaldoֹן זה.

תקופת התפתחותה העיקרית חלה בין אוגוסט למרס. הפטירה הטיפילית מת-גלה על הצמח בזרת נגנים בכיריים (בעיקר על העלה) ונגנים אפילים (בעיקר על הגבעול). הנגנים הבכיריים נובטים בתחום של  $1^{\circ}\text{C}$ – $30^{\circ}\text{C}$ . והטמפרטורה האופטימלית לנביותם היא  $7^{\circ}\text{C}$ – $13^{\circ}\text{C}$ . בעקבות המחלה גוברת הטרנספרציה של הצמחים הנגועים ובעלים הנתקפים נגימות הפרעות באגירת העמילן. בדיקות ציטולוגיות הוכחו שהפטירה פוגעת קשה בגרעין ובכולורופלטידות שבתאי העלים החולמים. על ידי רוסוטים ב-1%  $\text{CuSO}_4$  בתוספת סבון יrox, אפשר להפחית במקצת את הנזקים הנגרמים לוגולי לוע האРИה. על יסוד נסיוונות פרלימינריים במעבדה אפשר להניח כי הזנת הפונדקאי ב- $\text{KCl}$  ברכזים מתאים מגבירה את עמידתו בפני החלדוֹן.

## שתי מחלות כתמיים על עלי אירוס בארץ-ישראל

מאת ט. קושניר<sup>1</sup>

בעבודה זאת סוכמו התוצאות של ההסתכלויות וניסיונות שנעשו ע"י המחבר במיני הסוג אירוס. באסף האירוסים מכל חלקי הארץ שרככו בון הבוטני של האוני-ברסיטה ובגנה בכפר יוחאיל התגלו שתי מחלות על העלים. הנגרמות על ידי *Heterosporium gracile* Sacc. ו-*Septoria Iridis* C. Massalongo. נתנת סקירה על מיני האירוס שהותקפו בטבע על ידי פטריה זו או אחרת ועל המינים שלא הותקפו במחלה למורות ויותם בקשר צמחיים נגועים. הפטירות בודדו בתרבות נקייה ונעשו ניסיונות בהדבכה מלאכותית של מיני אירוסים שונים. תוצאות ההדבכה נתנות בטבלה בעמ' 232.

## האקולוגיה של הפרשת הצוף

מאת א. פאהן

1. הוכנה שיטה חדשה לבדיקה כמותית של הפרשת הצוף.
2. נקבעו כמותה ההפרשה הימית של צוף טרי ושל חומר יבש של 66 צמחים המצויים בארץ, והן: בגבולות 0.13 מ"ג צוף טרי — 0.10 מ"ג חומר יבש עד 267.75 מ"ג צוף טרי — 74.37 מ"ג חומר יבש לפרט.
3. מתרדר, כי כמות ההפרשה מותנית בין השאר בגודל הרקמה הצופנית.
4. נבדקה מידת הריכוז של החומר היבש שבצוף, שתונדתו הייתה בין 14% ל-87%.
5. היחס בין הסוכר המחור והבלתי מחר שbezof שונה בצמחים שונים. יש צמחים המפרישים סוכר מחר בלבד ולעומתם — המפרישים סוכר בלבד מחר בלבד, וכך לאלה שהפרשות מורכבות משני סוגים הסוכרים גם יחד, שיחסם שונה. במשפחות מסוימות היה שיבין שני סוגי הסוכרים שבצוף הוא קבוע פחות או יותר.
6. הובר, שאין קשר בין כמות הצוף המופרש ומידת ריכוזו מצד אחד ובין הקربה הטיסטומטית של מיני הצמחים מצד שני.
7. לחות האוויר משפיעה על ריכוז הצוף. בצופנים גלויים השפעתה גדולה מזו שבצופנים מוגנים.
8. הטמפרטורה היא בדרך כלל גורם המpreced את הפרשת הצוף.
9. רטיבות הקרקע מקדמת אף היא את הפרשת הצוף. היא נותנת את אותהיה לאחר השקתה הקרקע אלא כעבור יום יומיים.
10. ברוב הצמחים שבהם נבדק הריתמוס הימוי של ההפרשה נקבע, כי ההפרשה המקסימלית היא לרוב בשעות לפני הצהרים ואילו בצלף סיצילי (*Capparis sicula*) נקבעה ההפרשה המקסימלית בשעות הלילה.
11. במספר צמחים שפרוחיהם חים ימים אחדים נקבע, כי ההפרשה הגדולה ביותר הלה בדרך כלל ביום הראשון לפתיחה הפרה וההפרשה הקטנה ביום השני — באחרון ימי חייו של הפרח. בצמחים אלה אף נקבעו כמותה הצוף שפרוחיהם מפרישים במשך ימי חיים.
12. מידת ההפרשה של הפרה פוחתת והולכת ככל שההפרשה מתקרבת לגמר פריחתה.
13. בפרחים חד-מינניים באותו מין (*species*) של צמחים קיימים הבדלים ניכרים במידת ההפרשה של הצוף בין הפרחים הוכרים לבין הנקבים.
14. הפרשת הצוף בטקומית הנקה (*Tecomaria capensis*) לא מתכו כפי הנראה ללא לחץ השורש. מה שאין כן בצמחים אחרים, שדי להם בלחץ המקווי שבסביבת הצוף בלבד.
15. פצעת הצוף בטקומית הנקה (*Tecomaria capensis*) מעכבה כמעט לגמרי את הפרשת הצוף.

(4) אגד האשל המרובע (Tamaricion tetragynae). אגד זה מתחפה במלחות החזפה המתחאות בודיות שאין בהם נקיון ובדרסיות עמוקות. מלחות אלו מוצפפת מים במשך החלק מתקיפות החרף וגם בקץ הקרקע לח בזון (20% בחודש יוני). מליחות הקרקע גדולה במלחות אלו יותר מבקומות. כמוות המלחים הכלילית מגעת באחת החרבות שלו ל-5.78% ואך ל-7.51% וכמוות הכלior ל-2.17% ואך ל-2.86%. לאגד זה שיכות החרבות הבאות:

(א) חברת ב-ן-מלח מחייב — אשל מרובע (Arthrocnemum glaucum) — חברת (Tamarix tetragyna). חברת זו גדלה בדרסיות ובודיות המוצפים בחרף וכן גם בחופי ים המלח. הקרקע מלוח ולה במשך כל השנה. הערך האוסmotי של ב-ן-המלח גבוה למדי ואיננו משתנה הרבה במשך השנה (המינימום 50.4 אטמוספרות, המכ"ס 71.3 אטמוספרות). הצמחים האפיניים לחברת זו מובאים בעמוד 199.

(ב) חברת אשל ים המלח (Tamaricetum maris-mortui) נפוצה בשפכי הודיעות ובדרסיות מוצפפות בין ראש פשחה ויריחו.

(ג) חברת האוכם החד-ביבתי (Suaedetum monoicae) מופיעה בצורה פרג-מנטרית בלבד בקרבת ים המלח דרומה מקליה.

(ד) חברת הימלה הפגום (Nitriarietum retusae) מופיעה במקומות מורומים במקצת הסמכים לבתי הגידול של חברת ב-ן-המלח והאשל ושל חברת האוכם הא"י.

(ה) חברת האוכם השיחני (Suaedetum fruticosae) קרובה ביותר לחברות האגד של האוכם הא"י גם בתפוצתה וגם בתנאי בית הגדל שלה. היא מכסה את החוף הגבוה של ים המלח, ואת חגורת הצומח החיצונית של "גאון הירדן". היא חודרת גם לבתי הגידול התפוסים ע"י חברת המלוח הקפה.

mben שאר האגדים שבאזור הנסקר יוכרו:

(5) אגד הקנה והסמר (Junceto — Phragmition), המוגבל לגדות פלגים ומעינות המושכים מים מלוחים או מלוחים למחצה במשך כל השנה וכן לביצות מלוחות המוצפפות מים כל השנה.

(6) אגד צפצפת הפרת (Populion euphratica) המאכלס את אזורי התצפה בגדות הירדן ומהוות את "גאון הירדן". חברות החשובות ביותר הן חברת צפצפת הפרת (Tamaricetum jordanis) חברת אשל הירדן (Populetum euphratica) וחברת ינבות השדה והשוש הקרה (Prosopis farcata — Glycyrrhiza glabra).

(6) אגד הדרוך הנחלים (Nerion Oleandri) מוצג ע"י חברת שיח אברם המצויה באפיקי הנחלים מכושי החוץ שאינם מלוחים.

מי התהום הרחוקים יבש הקרקע בקץ (כמות המים מגיעה ל- $3.5\%$ — $3.7\%$  בחודש יוני).

את האגד הזה מיצגות החברות הבאות:

(א) חברת יפרוק המדבר ודוקרנו מדברי (*Anabasis articulata-Notoceras*)

(b) המתחשת במקומות שבהם הקרקע עמוק ועשיר בחצץ, הצמחים האפיניים מובאים בעמוד 192.

(ב) חברת מליחית אשונה—מלעניאל מצוי (*Salsola villosa-Stipa tortilis*)

הנפוצה בעיר בחלק הצפוני של השטח הנחקר. מצויים בה שני וריאנטים: אחד הקשור לקרקע מלה יותר והשני לקרקע שאיננו מלה בשטחים הסמוכים לאזוריים הסודניים-דקדנים. הצמחים האפיניים לחברת זו מובאים בעמוד 193.

(ג) חברת המלחית הקששנית (*Salsuletum tetrandrae*) חברת זו מצויה

רק בדרומו של השטח הנחקר ומאלכסת את החלק המזרחי הנמוך יותר של המדרגה העליונה ואת דאשי גבעות של האדמה השבורה". עובי שכבות האגרף בביית הגידול קטן מלה שבשתי החברות הקדומות והקרקע מלה בו יותר. המלחית הקששנית היא שטחת השרשים בגודל לצמחים הראשיים של החברות הקדומות שרשיהם מעוקים ו מגיעים לשכבות להוות יותר. בהתאם לכך היא עומדת בפני רכוז גבוח יותר של מלחים בתמיסת הקרקע ומתחשת בקץ ערכיים אוטומוטיים (מעל ל-100 אטמוספרות).

העלים בהרבה על אלה של המלחית האשונה ויפרוק המדבר.

(3) אגד האוכם הארץ-ישראלית והמלחית הקפה (*Atriplicetum — Suaedion*)

(*palaestinae*). אגד זה קשור למלהות מי התהום המצוויות בעיר במדרגה התחתונה ובדרישות של המדרגה העליונה. במלחות האלו קרובים מי התהום לפני הקרקע לפחות בחורף אף כי הקרקע אין מוצף מים. גם בקץ אין הקרקע מתיבש כدرך שמתיבש קרקע של המלחות האוטומורפיות (כמות המים מגיעה ל- $7\%-12\%$  בחודש יוני). הקרקע מלה יותר מקרקות המלחות האוטומורפיות; כמוות המלחים הכלילתי המומוצעת מתחודדת מ- $2.78\%$  עד  $3.02$  וכמות הכלור מ- $0.43\%$  עד  $1.04\%$ . ואלה

החברות הנמנות על האגד הזה:

(א) חברת האוכם הארץ-ישראלית (*Suaedetum palaestinae*). חברת זו נפוצה

יותר בדרכים ובשתי הדרישות שביןDOI ועוגה לודוי פרעה. הקרקע לח ותפוחה בחורף והסר טרכוטורה פיסיקלית בקץ. האוכם הוא שטחה שרשים. ומתחה ערכיים אוטומוטיים גבוחים למדוי (המכסימים שנמדד — 87.2 אטמוספרות), אף כי קרקע בית גידולו אין מתיבש באזמה המדה שמתיבש הקרקע של המלחית הקששנית. הצמחים האפיניים לחברת זו מובאים בעמוד 195.

(ב) חברת מליחת הרוסמרין (*Salsuletum Rosmarini*) חברת זו קרובה

לקודמת בהרכבה מיניה ובאפיינו של בית הגודל. היא מכסה רצועת ארצ מורחה לשטחי האוכם הארץ-ישראלית. המינים האופיניים לה מובאים בעמוד 196.

(ג) חברת המלחות הקפה (*Atriplicetum Halimi*). בתיה הגידול התפוסים עז

חברה זו רב-גוננים. היא מאכססת את הדריות המבתרים את האדמה השבורה" ומהוה חגורת חיצונית לדפרסיות התפוסות ע"י חברת האוכם הארץ-ישראלית ולשטחי התרבות שבדרגה העליונה. היא נפוצה מאר נס במושאי הודיית ובאזור השפך של הנחלים. המלה בעל רושע עמוק מאד והוא דורש קרקע שכבותיו העמוקות להוות. לעומת זאת אין הוא רגש בגראת לדטוי מלח נפרים.

מספר המינים אשר נרשם בשטח הנחקר הוא 187. מספר זה קטן בהשוואה למספר המינים בא"י כולה. ביחסו קטן מספר הרכבי-שנתנים. מספר המינים הכללי — 11.7% הם יסתיוכניים, 10% — אירוגו-טורגניים, 26% — סהרו-סינדיים ו-2% — סודטידקניים. 41% של המספר הכללי הן קבוצות קשר בין-אורויריות. מבין הטפוזים הביוולוגיים בולט המספר הגדל של החדרשניטים (82.3%) לעומתם 51.2% בא"י כלה) והמספר הקטן של המיקרופוטופיטים (1.6% לעומתם 23% בא"י ישראל כלה).

לפי דמותו שרשיהם מתחלקים הצמחים הרכבי-שנתניים בשטח הנחקר ל-4

טיפוסים:

- (1) טפוס האוכם שהשרש העיקרי שלו קצר מאד (5—25 ס"מ) והוא מסתעף לסעיפים אפקיים רבים וארכואים שאינם חודרים לעומק.
- (2) טפוס מליחת האשונה שהשרש העיקרי שלו חודר לעומק נכר 40—80 ס"מ ומסתעף אח"כ לסעיפים הגדלים בכוון אפקי או חודרים לעומק גדול יותר.
- (3) טפוס היפרוכם שהשרש העיקרי שלו חודר לעומק של מטרים אחדים וסעיפים תופסים שטח רחוב.
- (4) טפוס הינבוט המציגן בקנה שרש ארוך המסתעף בעומק של 30—80 ס"מ לסעיפים אפקיים עבים רבים המציגים נצרים ושוישים, והמסתעפים גם הם באפנ כה שנוצרת רשת מסובכת של קני שרש ושרשים בתוך הקרקע המגיעה לממדים גדולים ויכלה לאחפות שטח של מאות מטרים מרובעים ולהניע לעומק העולה על עשרה מטרים.

בדרך כלל נמוך הערך האוסומוטי בקנה של הצמחים עמוקיו והשרש בהשוואה להן של צמחים שטוחי השרש הגדלים באותו בית הגידול. אם כי הקשר בין הגידול (כמוות המלחים והמים בקרקע) ובין הצומח בולט מאד — קשה לחום לבדוק את תחומייהן של יחידות הצומח בגל רציפות המעבר שבין יחידה אחת לחברתה. קשי אחר בהגדרת יחידות הצומח נגרם בגל העובדה שבתי הגידול אינם אחידים לגביהם רכוו המלחים ומכות המים בשכבות הקרקע העליונה. כדי להתגבר על קשיים אלה וקשיים אחרים, היה הכרח לערך מפה של חבורות הצמחים וללמוד את התנאים האקולוגיים המתנוגים את תפוצתה של כל חבורה להלן מתחברים אגדי הצומח והחברות בצרוף נתונים אקולוגיים על בית הגידול והצמחים הראמים של החבורה.

(1) אגד השיטה הסלילנית (*Acacion tortilidis*). את האגד הסודונידקני *Zizyphus Spina* (Christi — *Balanites aegyptiaca*) התופסת את שטחיה המדרגה העליונה שקרקע הודח מליחים ע"י זרמי הנחלים הגדולים. כמוות המלחים הכללית בקרקע אינה עולה על 0.3% בממוצע וכמות הכלור על 0.05%. הצמחים האפיניים לחברה זו מובאים בעמוד 191.

(2) אגד המלחית האשונה (*Salsolion villosae*) החברות השיכות לאגד זה מאלומות את המלחות האוטומורפיות שבמדרגה העליונה. כמוות המלחים הכללית בקרקע מתנודדת מ- 0.16% עד 2.34% וכמות הכלור — מ- 0.0017% עד 1.05%. מפניהם

# עתון לבוטניקה

אדר תש"ט

סדרת ירושלים

כרך ד' חוב' ד'

## המבנה והאקולוגיה של הצומח באזורי ים-המלח

מאת מ. זהרי ו. ג. אורדנסקי

העבודה הזאת היא סכומו של מחקר על התלות שבין מבנה הצומח וה坦נים האקולוגיים בחבל הדרומי של בקעת הירדן, המשתרע מזרחה בדרום ועד ודי פרעה בצפונו וმתיירדן בדרום ועד למרגלות הרים במערב. שטח זה מתחולק מבחינה טופוגרפית לשש מדרגות הOLLOWות ווירדות מהרים לאפיק הירדן: (1) המדרגה העליונה, (2) המדרגה התת-העליונה, (3) אזור ההצפה של הירדן וים המלח (וור). השפה המורחית של המדרגה העליונה שבורה ממד כהו צאה מפעליות סחיפה חזקות והיא מכונה בפי היגיאולוגים בשם "אדמה שבורה". השטח הנידון מבוטר ע"י נחלים וערוצים רבים הזרמיים בעיקר ממערב למזרח. הגدولים שביהם, כמו ודי קלט, ודי עוג'ה ודי פרעה גרכו קרע ממהרים ושפכו את המלחים של סביבתם ויצרו (בעיקר במדרגה העליונה) נאות מדבר גדולים הבולטים לעין בתחום שטחי המלחות המקיפות אותו.

תנאי האקלים אחידים פחות או יותר בכל השטח ומצטיניהם בחרף דק וקיצ' חם (המינימום הממוצע —  $9.8^{\circ}\text{C}$  בינואר; המינימום הממוצע —  $31.8^{\circ}\text{C}$  ביוני; כמות הגשם הממוצעת מגעת ל- $65.2\text{ mm}$  לשנה בקהליה שבדרום ול- $140\text{ mm}$  בערך בדי פרעה שבצפונו. הסטיות מן הממוצע בשנים השונות גדולות מאד.

הסוג הראשי של הקרקע הוא והנוצר מתוכו "חוור הלשון". קרקע זה מכיל כמותות גדולות של גיר וגבש וגם כמותות ניכרות של מלחים נמסים שונים. במדרגה העליונה מכוסה חור לשון בשכבה של חמר קולוביאלי ואלובייאלי שנגרף מההרים שעוצמתה תולכת וקטנה ממערב לזרחה.

כל השטח, פרט לוה שמי הנחלים הדicho את מליחו הוא מלחה מטפסה הסולונצית שהמלח העיקרי בה הוא מלח השול (NaCl) המלווה בכמותות קטנות של  $\text{CaSO}_4$ ,  $\text{CaCl}_2$ ,  $\text{MgCl}_2$  וכו'. כמותות המלחים הנמסים משתנה בדרך כלל מ-0.2% ועד 15%. אולם היא יכולה להגיע גם עד ל-30% בערך (13.31 פופולס). היות ותנאי האקלים אחידים בכל השטח, הרי תפוצתן של חברות הצמחים נקבעת בעיקר ע"י הגורמים האדרפיים. כמוות המלחים והמים בקרקע, צורופיהם השוניים יוצרים מספר של בתים גדולים שלכל אחד מהם אפייניות יחידות צומח המאכליות אותן.



# עַתָּוֹן לְבָוטְבִּיקָה

## סדרת ירושלים

תcn של כרך ד'

עמור

השפעת מי השקאה מלווים על קליטת היוגנים על ידי נבט שוערה. מאות א. ר' ייפנברג  
 ור. רוזובטקי  
 החרבות המוניות ואמצעי ההבראה של השוטנית הצמחייה *Prymnesium parvum* בברכות  
 הדגים ארץ-ישראל. מאות ק. ר' ייך ום. אשנור  
 מפה גיאובוטנית של קרכעות ארץ-ישראל המעריבית. מאות מ. זהר  
 בדיקות פיסיקו-אנטומיות במנגנון התפוצה של פירות. מאות א. פאהן  
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 יג' צירקין  
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 אריא. א. קוגニיס וו. צירקין  
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 כ' Echinosciaidium. סוג חדש של סוככים מערבי. מאות מ. זהר  
 כ' המבנה והאוקולוגיה של הצומח באזורי ים-המלח. מאות מ. זהר וו. אורדנסקי  
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# עַתָּה זֶה לְבָרְטָבָרְקָה

סדרת ירושלים

יוצא לאור על ידי

חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית

ברוך ד

ירושלים

תש"ז / תש"ט

ירושלים

ת.ד. 620

# עתון לברוטנירקה

סדרת ירושלים

# עתון לботניקה

מוופיע בשתי סדרות

## א. סדרת ירושלים:

יוצאת לאור ע"י חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית ירושלים. בכל שנה מופיעות 4 חוברות וכל חוברת נושא עלייה את תאריך הופעתה. כל כרך שניי מכיל מ-300 עד 400 עמודים.

## ב. סדרת רחבות:

יוצאת לאור ע"י ה. ה. אופנהימר ווי. ריברט של התנהנה לחקר החקלאות, רחבות, א"י. בכל שנה מופיעות 2 חוברות וכל חוברת נושא עלייה את תאריך הופעתה. כל כרך שניי מכיל מ-200 עד 250 עמודים.

\*

במכתבים הוגעים לעוני המרכיב של סדרת ירושלים יש לפנות לד. ו. זיצק. ת. ד. 620, ירושלים — ולעוני המרכיב של סדרת רחבות לעורכי "עתון לבוטניקה", ת. ד. 15, רחבות.

\*

את דמי החתימה יש לשלם למפרע ע"י שק או המחאת דואר לפי הכתובת: ההגלה של העטון לבוטניקה, ת. ד. 620, ירושלים. מחיר החתימה הוא:  
2,000 ל"י לשנה, بعد שתי הסדרות  
1,250 ל"י לשנה, بعد סדרת ירושלים בלבד  
0,900 ל"י לשנה, بعد סדרת רחבות בלבד.  
בסכום זה נכללים גם דמי המשלחת.

\*

במכתבים עסקיים, בכלל זה הודיע על שינוי כתובת מודעות וכו' יש לפנות להגלה העטון לבוטניקה, ת. ד. 620, ירושלים.

# עתרן לברטברקה

סדרת ירושלים

יוצא לאור על ידי

חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית

## תcn

### עמוד

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כו  
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